TN 295
.U4

IC 8695, 1975

THE LIBRARY OF CONGRESS

IC 8695

Bird/Baker

Bureau of Mines Information Circular/1975

Coal Surface Mining Reclamation Costs

Appalachian and Midwestern Coal Supply Districts

UNITED STATES DEPARTMENT OF THE INTERIOR

United States. Bureau of Mines.

Information Circular 8695.

Coal Surface Mining Reclamation Costs

Appalachian and Midwestern Coal Supply Districts

By Robert J. Evans and John R. Bitler
Eastern Field Operation Center–Field and Environmental Activities,
Pittsburgh, Pa.

March 3 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
Thomas S. Kleppe, Secretary

Jack W. Carlson, Assistant Secretary–Energy and Minerals

BUREAU OF MINES
Thomas V. Falkie, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

TN 2
.U4
IC 8695, 1975

This publication has been cataloged as follows:

Evans, Robert J

Coal surface mining reclamation costs: Appalachian and Midwestern coal supply districts, by Robert J. Evans and John R. Bitler. [Washington] U.S. Bureau of Mines [1975]

50 p. illus., tables. (U.S. Bureau of Mines. Information circular 8695)

1. Strip mining—Appalachian region. 2. Strip mining—Middle West. 3. Reclamation of land—Appalachian region—Costs—Analysis. 4. Reclamation of land—Middle West—Costs— Analysis. I. U.S. Bureau of Mines. II. Bitler, John R., jt. auth. III. Title. (Series)

TN23.U71 no. 8695 622.06173

U.S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price $1.50
Stock Number 024-004-01805-4 Catalog Number I 28.27:8695

CONTENTS

Page

Abstract.... 1
Introduction.... 1
Costing factors and procedure.... 2
- Premining planning.... 2
- Backfilling.... 3
- Revegetation.... 4

Regional studies.... 4
- Region I, site 1.... 5
- Region II, site 1.... 5
- Region III, site 1.... 7

Reclamation cost analysis.... 10
Conclusion.... 14
Appendix A.--Glossary of reclamation and mining terms.... 16
Appendix B.--Supplemental regional studies.... 19

ILLUSTRATIONS

B-1. Mined land that is unreclaimed--the land has been abandoned after removal of the coal.... 21
B-2. Area mining pit prior to coal removal and reclamation.... 23
B-3. Contour mining--block stripping.... 25
B-4. Backfilling of an area mining pit.... 27
B-5. Stripping and backfilling adjacent pits utilizing bulldozers.... 29
B-6. Contour pit prior to backfilling (right), after backfilling (left) 31
B-7. Backfilling and grading of a pit mined by area mining.... 33
B-8. Topsoil replacement after backfilling and grading.... 35
B-9. Reclamation prior to revegetation but after backfilling, grading, and topsoil replacement.... 37
B-10. Agricultural activities on reclaimed land with area mining in the background.... 39
B-11. Reclaimed contour mining site with terrace.... 41
B-12. Reclaimed area mining site.... 46

TABLES

1. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 1 (1975).... 6
2. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 1 (1975).... 8
3. Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 1 (1975).... 9
4. Summary of unit cost parameters.... 11
5. Summary of physical site parameters and reclamation costs.... 12

B-1. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 2 (1975).... 20
B-2. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 3 (1975).... 22

TABLES--Continued

Page

B-3. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 4 (1975)................ 24
B-4. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 5 (1975)................ 26
B-5. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 6 (1975)................ 28
B-6. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 7 (1975)................ 30
B-7. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 8 (1975)................ 32
B-8. Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 9 (1975)................ 34
B-9. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 2 (1975)............... 36
B-10. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 3 (1975)............... 38
B-11. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 4 (1975)............... 40
B-12. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 5 (1975)............... 42
B-13. Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 6 (1975)............... 44
B-14. Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 2 (1975).............. 45
B-15. Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 3 (1975).............. 47
B-16. Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 4 (1975).............. 49
B-17. Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 5 (1975).............. 50

COAL SURFACE MINING RECLAMATION COSTS

Appalachian and Midwestern Coal Supply Districts

by

Robert J. Evans[1] and John R. Bitler[2]

ABSTRACT

Reclamation costs were estimated for 20 coal surface mining operations in the Appalachian and Midwestern Coal Supply Districts (these two districts were divided into three multi-State regions). The cost data were obtained through onsite observations, interviews with mining company personnel, and the authors' cost estimating procedures. The cost data are presented in terms of dollars per acre, dollars per ton of coal produced, and dollars per cubic yard of overburden moved during backfilling. The reclamation process is divided into three cost categories: Premining planning, backfilling, and revegetation. The average total reclamation costs for the three regions are $2.77 per ton of coal produced and $8,168 per acre. As the result of comparisons of reclamation costs by region, by mining method, by slope, and by size of operation, the most important reclamation cost difference is between area mining methods ($1.73 per ton) and contour mining methods ($3.81 per ton).

The Federal Bureau of Mines conducted this study to determine as accurately as possible the actual costs involved with the reclamation of coal surface mined land done in conjunction with active mining operations.

INTRODUCTION

During 1974, an estimated 295 million tons of coal, representing 50 percent of the total coal production, was strip mined in the United States. According to an estimate for the Project Independence Blueprint,[3] by 1985, 672 million tons (56 percent of the total estimated 1985 production) will be produced by strip mining. An important and required function of strip mining is the reclamation of the mine site in conjunction with mining operations in order to eliminate the devastation that has been associated with prelaw strip mining.

---

[1] Mechanical engineer (now with Energy Research and Development Agency).

[2] Physical scientist, Eastern Field Operation Center--Mineral and Materials Supply/Demand Analysis.

[3] Project Independence Blueprint estimates made by the Federal Energy Administration represent the intermediate coal supply scenario.

The reclamation costs presented in this study are for 20 mine sites located within the Appalachian and Midwestern Coal Supply Districts. During 1973 (the latest period for which individual district production data are available) 211 million tons of coal (76 percent of the total U.S. strip mine production) was strip mined in these districts; by 1985, strip mining in the study area is expected to increase production to 393 million tons (58 percent of the estimated total U.S. strip mine production for 1985).

The cost information presented for area and contour mining methods is based upon onsite observations, interviews with company personnel at each site, and the authors' cost estimation procedures. For each of the 20 sites, cost data are presented in tabular form including a narrative that describes the site conditions. The reclamation process is split into the following phases for which costs are provided: Premining planning, backfilling, and revegetation. The costs are summarized per acre of total land reclaimed,[4] per ton of coal produced, and per cubic yard of material moved during backfilling, grading, and topsoil stockpiling. Photographs are included to illustrate the various phases comprising the reclamation process. A glossary of the coal surface mining and reclamation terms used in the text is available in appendix A.

The Bureau of Mines has undertaken this study to determine, as accurately as possible, the actual costs of reclaiming strip mined land in conjunction with active mining operations. The factors that result in the variation of the cost data are (1) the physical, economic and managerial properties that differentiate a particular mining operation from any other mining operation, and (2) the lack of detailed, current reclamation cost records at many of these mines. Information obtained from field interviews is presented in a manner to avoid divulging individual company names and mine locations.

COSTING FACTORS AND PROCEDURE

For this study, reclamation is defined as the work required by law to restore the surface of mined land to the conditions that existed prior to mining or to a higher use of the land.[5] To evaluate reclamation methods in terms of the ability to meet current and future reclamation standards, the cost of the operations comprising the reclamation process must be determined.

Premining Planning

Planning for the reclamation of a mine site prior to the commencement of mining generally increases the effectiveness and reduces the total cost of the reclamation program. Factors contributing to the costs of premining planning include (1) an engineering study that involves mapping the mine site, a study of the site's drainage pattern, and the development of the data required to support the mining permit application; (2) the design and construction of pollution control systems, drainage systems, and sedimentation control impoundments, and (3) the costs of bonding, permits, and applications required by State and Federal regulations.

---

[4] Total land reclaimed refers to the total amount of land affected (in addition to the number of acres mined) that is reclaimed. Reclamation costs and amounts of land reclaimed as reported in this study are on an annual basis unless otherwise noted.

[5] In some cases, mining is conducted in areas that were previously mined but not reclaimed; reclamation in these cases results in land that can be utilized in a productive manner.

The costs of premining planning were divided into the following three categories, for which the total cost and cost per acre are shown: Engineering design, antipollution measures, and bonds, fees, and permits. Total premining planning costs are presented in terms of the cost per acre and the cost per ton of coal produced. The cost data were obtained during onsite interviews and from the bonding and permit requirements detailed by the reclamation law of the State in which the mine site is located.

Backfilling

Each mining operation has a specific combination of equipment that, depending upon the site characteristics, enables mining and reclamation to be conducted most efficiently. Factors affecting the choice of backfilling equipment are overburden conditions, mining method being utilized, slope, and existing reclamation laws. The economic feasibility of any combination of equipment is reflected by the cost per cubic yard of overburden moved.

The total backfilling costs are presented for each mining operation in terms of the cost per acre, the cost per cubic yard of material moved, and the cost per ton of coal produced. The backfilling costs were determined by estimating the operating and ownership costs of the equipment utilized for backfilling in conjunction with the amount of time this equipment devoted to reclamation. The estimates of the time this equipment devoted to reclamation were obtained from representatives of the mining company operating at each site. The operating and ownership costs for all equipment, with the exception of draglines and shovels with capacities of greater than 6 cubic yards, were obtained from the Construction Equipment Cost Reference Guide.[6] The operating cost includes the costs of maintenance labor and supplies, lubrication, operating labor (obtained separately for each site), fuel, and tires (where applicable). The ownership cost includes depreciation, interest, insurance, and taxes. The operating and ownership costs obtained from the Construction Equipment Cost Reference Guide represent costs for new equipment. For draglines and shovels with capacities greater than 6 cubic yards, the operating and ownership costs were based upon the actual age of the equipment and upon data obtained as the result of discussions with mining and equipment manufacturing company representatives. The depreciation for these draglines and shovels was based upon an operating life of 40,000 hours. The exact capacities of the draglines and shovels were not indicated in order to avoid divulging information from which the identities of individual mining operations and firms could be determined.[7]

---

[6] National Research and Appraisal Company. Construction Equipment Cost Reference Guide. Palo Alto, Calif., 1974, 540 pp.

[7] Capacities of draglines and shovels are reported in the following manner:

Small....................	0-20 cubic yards.
Medium..................	21-50 cubic yards.
Large....................	51 or greater cubic yards.

Revegetation

Revegetation includes a combination of the following operations (depending upon revegetation requirements): Disking, liming, fertilizing, mulching, and seeding. The equipment utilized ranges from conventional tractor-pulled farm equipment to specialized equipment such as a helicopter-mounted hydroseeder. The type of revegetation equipment utilized at a site is identified in the narrative that accompanies the tabular data for each of the 20 sites. The choice of technique and equipment is determined by site accessibility, water availability, slope, size of the area to be revegetated, and the time of the year during which revegetation operations are conducted.

The revegetation cost data were obtained through discussions with representatives of the mining companies, State reclamation associations, and farm equipment manufacturing companies. The cost data are presented in each table as identifying the primary piece of equipment, the average cost per acre and cost per hour of all of the revegetation equipment utilized, the per-acre costs (excluding applications cost, which is reflected by the equipment cost) of fertilizer, lime, and mulch, and the seeding costs (including seed and application costs) per acre. The total revegetation costs are presented as cost per acre and cost per ton of coal produced.

All of the cost data presented in this study were estimated during the first quarter of 1975. In cases in which accurate cost data were not available, estimates of these cost data were made based upon the data provided by the other mining company representatives interviewed during the course of the study.

REGIONAL STUDIES

Reclamation cost data and information relating to premining planning, backfilling, and revegetation were obtained for 20 mining operations located within the Appalachian and Midwestern Coal Supply Districts. These operations ranged in annual production from 14,000 to 6,000,000 tons, in slope from 5° to 25°, and involved area and contour mining methods. The two coal supply districts were divided into three multi-State regions. Mine sites were not classified by individual States in order to avoid disclosing individual site locations and mining company identities. The three regions are composed of the following States:

Region I --Alabama, Kentucky, and Tennessee.

Region II --Maryland, Pennsylvania, Virginia, and West Virginia.

Region III--Illinois, Indiana, and Ohio.

The reclamation cost data for these sites are tabulated and converted into total reclamation costs presented in terms of dollars per acre, dollars per cubic yard of overburden moved during backfilling, and dollars per ton of coal produced. Following are the explanations and cost tables for 3 selected mining operations; the explanations and cost tables for the remaining 17 sites are contained in appendix B.

Region I, Site 1

Conventional contour mining, which requires the reclamation of 65 acres annually, is conducted in an area with an average slope of 25°. The overburden, consisting primarily of shale and sandstone, covers two coalbeds with a cumulative average thickness of 4 feet. The mining operation involves two highwalls with a cumulative average height of 48 feet and production of 130,000 tons of coal annually.

The backfilling operation utilizes bulldozers and front-end loaders with no spoil being placed more than 125 feet downslope from the cropline of the lower coalbed. The mine is scheduled to operate 10 hours per day, 300 days per year. Approximately 20 feet of the highwall remains after final grading, resulting in a flat bench void of large rocks. Prior to mining, the area was primarily woodland; after reclamation, the land will be suitable for use as pasture. The revegetation process utilizes a hydroseeder that performs the fertilizing, seeding, and mulching operations. Some of the reclaimed area requires seeding more than once, primarily as the result of erosion on the relatively steep slope prior to the initial growth of vegetation.

The estimated costs on a dollar-per-acre basis for the reclamation operations obtained from table 1 are $721--preming planning, $6,684--backfilling, and $355--revegetation. The total cost of reclamation is $7,760 per acre, $0.28 per cubic yard of overburden moved during backfilling, or $3.88 per ton of coal produced.

Region II, Site 1

Area mining, which requires the annual reclamation of 180 acres, is conducted on gently rolling terrain with a slope averaging 9°. Annual production of 800,000 tons is obtained from one coalbed 4.2 feet in average thickness, which is overlain by gray shale and sandstone. The highwall height averages 55 feet.

The mining and backfilling equipment includes a dragline, a scraper, and bulldozers. The dragline is scheduled to operate three 8-hour shifts per day, 350 days per year. The scraper is scheduled to work two shifts per day, 300 days per year. All other equipment is scheduled to work three shifts per day, 300 days per year. Reclamation returns the land to its approximate original contour. Prior to mining, the area consisted primarily of woodland; after reclamation, the land will be suitable for utilization as pasture. The revegetation process involves disking, rock picking, liming; seeding with a grain drill, and mulching accomplished using equipment pulled by a farm tractor.

TABLE 1. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 1 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-conventional	5,850	90	37,505	577	3,510	54	721	-	0.36

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	385 hp...	3	3.0	4.39	5.47	28.19	4.78	15.88	176.13	528.29	-	-	-
Front-end loader....	10 cu yd.	2	3.0	7.06	5.47	58.82	5.92	19.43	193.40	580.20	-	-	-
Do...............	12 cu yd.	1	3.0	8.36	5.47	68.44	7.14	23.81	113.22	339.66	-	-	-
									482.75	1,448.15	6,684	0.28	3.34

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	55	-	140	100	355	-	0.18
Total reclamation costs..							7,760	0.28	3.88

The estimated reclamation costs per acre as presented by table 2 are $181--premining planning, $4,915--backfilling, and $346--revegetation. The total cost of reclamation is $5,442 per acre, $0.15 per cubic yard of overburden moved during backfilling, or $1.23 per ton of coal produced.

Region III, Site 1

Area mining, requiring the annual reclamation of 220 acres, is conducted on rolling terrain with an average slope of 10°. Annual production of 720,000 tons of coal is obtained from one coalbed averaging 3 feet in thickness. Stripping, through shale and sandstone primarily, results in a highwall that averages 50 feet in height.

The backfilling equipment includes a dragline, grader, front-end loader, bulldozers, and scrapers. The mine is scheduled to operate two 10-hour shifts per day, 300 days per year. Reclamation returns the land to its approximate original contour and involves the segregation and stockpiling of topsoil. The land, which was utilized for grazing prior to mining, will be returned to pasture after reclamation. The revegetation process includes disking (3 times), rock picking, liming, seeding, and manual mulching.

The reclamation costs on a per-acre basis obtained from table 3 are $277--premining planning, $7,031--backfilling, and $370--revegetation. The total cost of reclamation is $7,678 per acre, $0.22 per cubic yard of overburden moved during backfilling, and $2.34 per ton of coal produced.

TABLE 2. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 1 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area...............	7,200	40	9,450	53	15,840	88	181	-	0.04

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dragline...........	Medium...	1	4.8	28.41	11.20	39.34	69.80	34.90	183.65	881.52	-	-	-
Dozer..............	385 hp...	2	7.2	4.39	6.20	28.19	4.78	15.88	118.88	855.94	-	-	-
Scraper............	35 cu yd.	1	14.4	5.70	6.20	41.29	5.42	15.34	73.95	1,064.88	-	-	-
									(1)	(1)	4,915	0.15	1.11

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, grain drill, lime spreader..........	20	60	52	48	100	86	346	-	0.08
Total reclamation costs....................................							5,442	0.15	1.23

[1] These columns are not totaled because different pieces of equipment operate a different number of days each year.

TABLE 3. - Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 1 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area and block cut..	43,200	180	11,280	47	12,000	50	277	-	0.08

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Scraper............	31 cu yd.	2	18.0	4.73	5.47	34.08	4.47	12.66	122.82	2,210.76	-	-	-
Dozer..............	385 hp...	4	6.0	4.39	5.47	28.19	4.78	15.88	234.84	1,409.04	-	-	-
Front-end loader....	10 cu yd.	1	6.0	7.06	5.47	58.82	5.92	19.43	96.70	580.20	-	-	-
Grader.............	180 hp...	1	6.0	2.03	5.47	13.22	1.13	3.84	25.69	154.14	-	-	-
Dragline...........	Small....	1	4.0	8.74	10.47	132.83	11.86	36.60	200.50	802.00	-	-	-
									680.55	5,156.14	7,031	0.22	2.15

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, rock picker, lime truck, grain drill.	20	90	60	40	100	80	370	-	0.11
Total reclamation costs..							7,678	0.22	2.34

RECLAMATION COST ANALYSIS

The cost information and physical parameters for the 20 mining operations considered by this study are summarized in tables 4-5. Table 4 provides cost information for each operation and cost averages for the following categories: Total average (18 operations),[8] for area and contour mining methods, by region, for slopes greater than 20° and less than 20°, and by size of operation (greater than 500,000 tons per year and less than 500,000 tons per year). Table 5 provides the following physical parameters in addition to the total reclamation costs for each operation: Affected acreage, average slope, average highwall height, number of coalbeds, cumulative coalbed thickness, annual coal production, and the amount of the highwall that remains exposed after reclamation.

Reclamation costs are often presented in terms of the dollars per acre required to return the land affected by mining and its auxiliary operations to an acceptable condition. Such costs are less useful than those expressed in dollars per ton of coal produced, especially when utilized for assessing the impact of reclamation costs on coal mining operations and for making comparisons of the reclamation costs for different operations. The use of the dollar-per-acre cost basis may foster the mistaken impression that the reclaimed land has the value of the amount of reclamation performed on this land. Usually the value of the land reclaimed is considerably less than the cost of reclaiming this land. Stating reclamation costs in dollars per ton provides greater comparability with the other costs of mining and the revenues received from the sale of the coal, clarifying the relationship between reclamation costs and the cost of coal.

The following example, based upon the information in tables 4-5, will illustrate some of the misimpressions that are associated with reclamation costs presented in terms of dollars per acre.

Location	Total reclamation costs		Coalbed thickness, feet	Highwall height, feet
	Dollars per acre	Dollars per ton		
Site 1, region III.............	7,678	2.34	3	50
Site 3, region III.............	14,650	2.01	7	100

Considering the reclamation costs only in terms of dollars per acre, it appears that these costs have a much greater impact on the producer at site 3 than on the producer at site 1. However, when the reclamation costs are stated in dollars per ton, the actual impact upon the respective producers can be observed. Stating reclamation costs in dollars per ton has the advantage of taking into account the amount of coal produced; these costs are then spread over the same units that produce revenue. Although the producer at site 3 has a much higher cost per acre (affected to a certain extent by the greater highwall height), this producer's cost per ton is lower as a result of obtaining more coal through the mining of a thicker coalbed.

---

[8] Sites 4 and 6 in region I are not included in the cost averages because these sites are operating under special conditions, which result in current mining being unprofitable.

TABLE 4. - Summary of unit cost parameters

Region	Site	Mining method	Acres	Average slope	Premining		Backfilling		Revegetation		Total reclamation costs		
					Dollars per ton	Dollars per acre	Dollars per ton	Dollars per acre	Dollars per ton	Dollars per acre	Dollars per ton	Dollars per acre	Dollars per cu yd
I	1	Contour..........	65	25	0.36	721	3.34	6,684	0.18	355	3.88	7,760	0.28
	2	.....do..........	10	25	.19	186	3.72	3,723	.33	330	4.24	4,239	.34
	3	.....do..........	120	24	.29	508	4.27	7,396	.18	320	4.74	8,224	.31
	[1]4	.....do..........	10	25	.35	375	10.52	11,136	.40	420	11.27	11,931	.69
	5	.....do..........	180	25	.07	325	3.16	14,317	.09	430	3.32	15,072	.32
	[1]6	.....do..........	120	25	.08	167	5.76	11,994	.15	320	5.99	12,481	.37
	7	Area..............	90	10	.05	131	.94	2,625	.03	74	1.02	2,830	.13
	8	.....do..........	40	10	.04	257	1.26	7,872	.05	335	1.35	8,464	.20
	9	.....do..........	360	10	.13	444	1.92	6,838	.01	47	2.06	7,329	.26
Region I average...............			-	-	.16	367	2.66	7,065	.12	270	2.94	7,703	.26
II	1	Area..............	180	9	.04	181	1.11	4,915	.08	346	1.23	5,442	.15
	2	Contour..........	90	25	.10	205	3.75	7,510	.17	335	4.02	8,050	.31
	3	.....do..........	6	20	.08	200	2.47	6,163	.15	370	2.70	6,733	.19
	4	.....do..........	12	15	.05	173	3.20	11,996	.03	100	3.28	12,269	.37
	5	Area..............	29	10	.05	188	2.15	7,990	.06	228	2.26	8,406	.25
	6	.....do..........	100	8	.04	168	1.96	7,831	.07	269	2.07	8,286	.18
Region II average..............			-	-	.06	186	2.44	7,734	.09	275	2.59	8,198	.24
III	1	Area..............	220	10	.08	277	2.15	7,031	.11	370	2.34	7,678	.22
	2	Contour..........	460	15	.12	165	3.78	5,353	.27	388	4.17	5,906	.21
	3	Area..............	150	5	.05	333	1.94	14,206	.02	111	2.01	14,650	.23
	4	Contour..........	2,400	17	.12	302	3.80	9,488	.06	146	3.98	9,936	.18
	5	Area..............	192	5	.06	283	1.14	5,354	.03	119	1.23	5,756	.16
Region III average.............			-	-	.09	272	2.56	8,286	.10	226	2.75	8,785	.20
Total average, all sites........			-	-	.11	280	2.56	7,627	.11	260	2.77	8,168	.24
Average--area mining..........			-	-	.06	251	1.62	7,185	.05	211	1.73	7,649	.20
Average--contour mining.......			-	-	.15	309	3.50	8,070	.16	308	3.81	8,688	.28
Average--sites with slope ≥20°			-	-	.18	358	3.45	7,632	.18	357	3.81	8,346	.29
Average--sites with slope <20°			-	-	.07	242	2.11	7,625	.07	211	2.25	8,079	.21
Average-ssites with production ≥500,000 tons per year.......			-	-	.08	289	2.38	8,438	.08	245	2.54	8,971	.22
Average--sites with production <500,000 tons per year.......			-	-	.13	274	2.71	6,979	.13	270	2.96	7,526	.26

[1] Averages do not include data from sites 4 and 6 in region I because these mine sites are operating under special conditions that result in a loss of money for present mining.

TABLE 5. - Summary of physical site parameters and reclamation costs

Region	Site	Method of mining	Site parameters							Reclamation costs		
			Acres	Average slope, degrees	Average highwall height, feet	Number of coalbed mined	Cumulative coalbed thickness, feet	Annual coal tonnage	Degree of reclamation highwall exposed, feet	Dollars per acre	Dollars per cubic yard	Dollars per ton of coal mined
I	1	Contour-conventional.............	65	25	48	2	4.0	130,000	20	7,760	0.28	3.88
	2	.....do.........................	10	25	60	1	3.5	[1]30,000	20	4,239	.34	4.24
	3	Contour-scraper haulback..........	120	24	55	1	2.5	208,000	20	8,224	.31	4.74
	4	Contour-block cut with head of hollow fill.....................	10	25	55	1	1.6	[2]14,115	0	11,931	.69	11.27
	5	Contour-block cut, truck haulback, and head of hollow fill..........	180	25	48	3	4.5	[3]543,369	0	15,072	.32	3.32
	6	Contour-conventional and truck haulback with dragline and shovel	120	25	50	1	2.5	250,000	20	12,481	.37	5.99
	7	Area............................	90	10	50	1	2.2	200,000	0	2,830	.13	1.02
	8	.....do.........................	40	10	70	2	5.0	250,000	0	8,464	.20	1.35
	9	.....do.........................	360	10	50	1	2.5	1,284,000	0	7,329	.26	2.06
II	1	Area............................	180	9	55	1	4.2	800,000	0	5,442	.15	1.23
	2	Contour-block cut with truck haulback........................	90	25	50	1	3.0	180,000	0	8,050	.31	4.02
	3	Contour-block cut................	6	20	40	2	3.2	15,000	0	6,733	.19	2.70
	4	.....do.........................	12	15	50	1	3.0	45,000	0	12,269	.37	3.28
	5	Area............................	29	10	50	1	3.5	108,000	0	8,406	.25	2.26
	6	.....do.........................	100	8	75	3	6.0	400,000	0	8,286	.18	2.07
III	1	Area............................	220	10	50	1	3.0	720,000	0	7,678	.22	2.34
	2	Contour.........................	460	15	70	1	4.0	650,000	0	5,906	.21	4.17
	3	Area............................	150	5	100	1	7.0	1,100,000	0	14,650	.23	2.01
	4	Contour.........................	2,400	17	60	2	4.0	5,980,000	0	9,936	.18	3.98
	5	Area............................	192	5	55	1	5.0	900,000	0	5,756	.16	1.23

[1] Projected annual tonnage based on 4 months' production.
[2] Projected annual tonnage based on 9 months' production.
[3] Projected annual tonnage based on 18 months' production.

The average reclamation costs for all of the operations considered by this study (except for sites 4 and 6 in region I) are $2.77 per ton of coal produced, $8,168 per acre, and $0.24 per cubic yard of material moved during backfilling. The operations comprising backfilling (backfilling, grading, and topsoil movement) account for 92 percent of the average total reclamation costs. Premining planning and revegetation account for a relatively modest 8 percent of the average total reclamation costs. The large contribution of backfilling costs to the total reclamation costs is the result of the greater amounts of time which the more expensive equipment must spend performing backfilling operations relative to the other reclamation operations.

The average costs for each region for premining planning, backfilling, revegetation, and the average total reclamation costs follow:

Region	Premining planning, dollars per ton	Backfilling, dollars per ton	Revegetation, dollars per ton	Total, dollars per ton
I..................	0.16	2.66	0.12	2.94
II.................	.06	2.44	.09	2.59
III................	.09	2.56	.10	2.75

The costs in regions II and III are not appreciably different; the somewhat higher costs for region I are most likely due to the greater number of contour mining operations conducted on steeper slopes (≥20°) included in the region I data.

The most significant reclamation cost differences, based upon the information obtained during this study, result from differences in slope and differences in mining method. The slope and mining method employed are directly related; area mining methods are employed on terrain that is flat or gently rolling, and contour mining is employed on terrain with steeper slopes. The following are the comparisons of the average reclamation costs for area and contour mining methods and for reclamation done on slopes of 20° or greater and on slopes of less than 20°.

Description	Premining planning, dollars per ton	Backfilling, dollars per ton	Revegetation, dollars per ton	Total dollars per ton
Area...............	0.06	1.62	0.05	1.73
Contour............	.15	3.50	.16	3.81
Less than 20°......	.07	2.11	.07	2.25
20° or greater.....	.18	3.45	.18	3.81

The ranges of total reclamation costs for area and contour mining methods and for slopes of 20° or greater and less than 20° follow:

Description	Total reclamation costs, dollars per ton
Area..............	1.02-2.34
Contour...........	2.70-4.74
Less than 20°......	1.02-4.17
20° or greater.....	2.70-4.74

The difference in reclamation costs between area and contour mining methods is readily apparent. The utilization of large-scale overburden handling equipment (draglines and shovels) in conjunction with the efficiencies of being able to place overburden in the previously mined cut and being able to operate on relatively flat terrain contribute to the lower reclamation costs for area mining methods. The ranges of reclamation costs for slopes of 20° or greater and for slopes less than 20° overlap primarily as the result of several contour mining operations of relatively high cost operating on slopes of 15° to 17°.

The comparison of the average reclamation costs for mining operations with annual coal production of greater than 500,000 tons and less than 500,000 tons follows:

Description	Premining planning, dollars per ton	Backfilling, dollars per ton	Revegetation, dollars per ton	Total, dollars per ton
Greater than 500,000 tons per year......	0.08	2.38	0.08	2.54
Less than 500,000 tons per year......	.13	2.71	.13	2.96

The reclamation costs for the larger operations (greater than 500,000 tons per year) are somewhat lower than the costs for the smaller operations (less than 500,000 tons per year). This may be an indication of the existence of economies of scale for reclamation; however, the diversity of conditions and the combination of area and contour mining methods encompassed by both the larger and the smaller production categories prevents the development of any definite conclusions relating to reclamation economies of scale.

CONCLUSION

The determination of reclamation costs and the comparison of these costs is at best a difficult process in view of the complex combination of physical, economic, and management properties affecting each mining operation. It is apparent from the cost information developed in this study that reclamation is a required process that is also a significant component of the cost of mining coal.

The analysis of the cost data for the 20 mining operations considered by this study resulted in the following conclusions:

1. Expressing reclamation costs in terms of dollars per ton of coal produced is more practical than expressing these costs in dollars per acre.

2. The most significant reclamation cost difference results from the comparison of the costs of reclaiming land mined utilizing area mining methods and contour mining methods. The slope of the terrain upon which mining is conducted also results in cost differences; however, these differences are reflected by the mining method with area mining done on flat land or land with lower slopes and contour mining done on steeper slopes. The reclamation costs

involved with area mining (averaging $1.73 per ton) are much lower than the reclamation costs involved with contour mining ($3.81 per ton).

3. The comparison of the reclamation costs by region and by size of mining operation did not yield appreciable differences.

4. Reclamation costs have been divided into three categories: Premining planning, backfilling, and revegetation. Of the three, backfilling is the most costly; on the average, backfilling accounts for 92 percent of the total reclamation costs.

APPENDIX A.--GLOSSARY OF RECLAMATION AND MINING TERMS[1] [2]

Abandoned mine.--A mining operation where coal is no longer being produced and it is the intent of the operator not to continue production from the mine.

Acid mine drainage.--Any acid water draining or flowing on, or having drainage or flowed off, any area of land affected by mining.

Acid spoil.--Usually spoil material containing sufficient pyrite so that weathering produces acid water and the pH of the soil as determined by standard methods of soil analysis is below 6.9.

Active surface mine.--A mining operation where land is being affected in preparation for and during the removal of a mineral.

Affected land.--Land on which excavation has occurred or upon which overburden has been deposited or both.

Area mining.--Surface mining that is carried on in level to gentle rolling topography on relatively large tracts.

Auger mining.--Generally practiced but not restricted to hilly coal-bearing regions of the country. Utilizes a machine designed on the principle of the auger, which bores into an exposed coal seam and conveys the coal to storage site or bin for loading and transporting. May be used alone or in combination with conventional surface mining. When used alone, a single cut is made sufficient to expose the coal seam and provide operating space for the machine. When used in combination with surface mining, the last cut pit provides the operating space.

Backfill.--The operation of refilling an excavation, including the grading of the refilled excavation. Also the material placed in an excavation in the process of backfilling.

Bench.--The surface of an excavated area at some point between the material being mined and the original surface of the ground on which equipment can move or operate. A working road or base below a highwall as in contour stripping for coal.

Bench method, extended.--The use of a large capacity walking dragline in deep overburden operating from a machine-supporting bench formed by filling the V between the bank and the spoil. This V-section is formed from material that falls from the bank or is placed by the dragline and must be rehandled. Rehandling averages approximately 10 to 25 percent of the solid bank, depending on the height of the bench.

---

[1] Bituminous Coal Research, Inc. Glossary of Surface Mining and Reclamation Technology. Ed. by Council for Surface Mining and Reclamation Research in Appalachia, pub. by National Coal Association for the Coal and Environmental Conf., Louisville, Ky., October 1974, 25 pp.

[2] Grim, E. C., and R. D. Hill. Environmental Protection in Surface Mining of Coal. U.S. Environmental Protection Agency, Program Element No. 1BB040, Cincinnati, Ohio, October 1974, 291 pp.

Block cut method.--This method of surface mining removes overburden and places it around the periphery of a box-shaped cut. After coal is removed, the spoil is pushed back into the cut and the surface is blended into the topography.

Box cut.--The initial cut driven in a property, where no open side exists; this results in a highwall on both sides of the cut.

Broadcasting seeding.--Scattering seed on the surface of the soil. Contrasted with drill seeding, which places seed in rows in the soil.

Contour mining.--The removal of overburden and mining from a coal seam that outcrops or approaches the surface at approximately the same elevation, in steep or mountainous areas.

Conventional mining.--Method of contour stripping that consists of removing the overburden from the mineral seam, starting at the outcrop and proceeding around the hillside. Overburden is cast down the hillside and stacked along the outer edge of the bench, successive cuts are made until the depth of overburden becomes too great for economic recovery of the coal.

Cropline.--(See Outcrop.)

Haulback mining method.--This method removes coal by stripping and augering with no material being placed on the downslope. Haulback methods reduce affected acreage by nearly two-thirds when compared with conventional surface mining because the overburden is hauled by truck laterally along the bench and then backfilled against the highwall.

Head of the Hollow.--(Valley fill.) Overburden material from adjacent contour or mountaintop mines is placed in compacted layers in narrow steep-sided hollows so that surface drainage is possible.

Highwall.--The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a contour strip mine excavation.

Hydroseeding.--Dissemination of seed hydraulically in a water medium. Mulch, lime, and fertilizer can be incorporated into the sprayed mixture.

Legume.--A member of the legume or pulse family, leguminosae. One of the most important and widely distributed plant families. Includes many valuable food and forage species, such as the peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudza. Practically all legumes are nitrogen-fixing plants.

Modified block cut.--This method of surface mining adapts the block cut method to steeply sloped areas. The modification essentially is backfilling with spoil from succeeding blocks rather than from the spoil-producing block.

Mountaintop removal.--In this mining method, 100 percent of the overburden covering a coal seam is removed in order to recover 100 percent of the mineral. Excess spoil material is hauled to a nearby hollow to create a valley fill.

Mulch.--A natural or artificial layer of plant residue or other materials placed on the soil surface to protect seeds, to prevent blowing, to retain soil moisture, to curtail erosion, and to modify soil temperature.

Multiple-seam mining.--Surface mining in areas where several seams are recovered from the same hillside.

Original contour.--Involves backfilling and grading a mined area to return this area to its original topography.

Outcrop.--Coal that appears at or near the surface. The intersection of a coal seam with the surface.

Outslope.--(Downslope.) The exposed area sloping away from a bench cut section.

Overburden.--The earth, rock, and other materials that lie above the coal.

Pit.--Used in reference to a specifically describable area of opencut mining. May be used to refer to only that part of the opencut mining area from which coal is being actively removed or may refer to the entire contiguous mined area.

Prelaw.--Term used to refer to strip mine operations conducted previous to the passage of a State's reclamation act.

Reclamation.--The process of reconverting mined land to its former or other productive uses.

Slope.--The inclination of a stream channel or ground surface, usually expressed in terms of the ratio or percentage of number of units of vertical rise or fall per unit of horizontal distance.

Strip mine.--Refers to a procedure of mining that entails the complete removal of all material from over the product (in this case, coal) to be mined in a series of rows or strips; also referred to as open cut, open pit, or surface mine.

Swale.--A slight marshy depression in generally level land.

APPENDIX B.--SUPPLEMENTAL REGIONAL STUDIES

Region I, Site 2

Contour mining of a single coalbed annually affects 10 acres of an abandoned site, which has an average slope of 25°. The overburden is gray shale and sandstone with the coalbed thickness averaging 3.5 feet and yielding approximately 30,000 tons of coal.

The mining operation utilizes bulldozers and front-end loaders as the stripping and backfilling equipment with production supplemented by augering. As the coal is uncovered, a new cut is taken into the highwall, which averages 60 feet in height. Approximately 20 feet of the highwall remains exposed after the final grading, resulting in a flat bench void of rocks. Although coal is not obtained from the entire area, the site is completely reclaimed. After reclamation, the site can be used for grazing or farming. The working schedule is 10 hours per shift, one shift per day, 6 days per week, 50 weeks per year. Revegetation is accomplished by disking and using a hydroseeder to fertilize, seed, and mulch.

The estimated cost breakdown in dollars per acre for reclamation from table B-1 is as follows: Premining--$186, backfilling--$3,723, and revegetation--$330. The total cost of reclamation was estimated to be $4,239 per acre, $0.34 per cubic yard of overburden, or $4.24 per ton of coal mined.

Region I, Site 3

This contour mining operation affects 120 acres of land with an average slope of 24°. The overburden is gray shale and sandstone with a coalbed that averages 2.5 feet in thickness and yields 208,000 tons of coal annually.

Mining involves the scraper haulback method of contouring utilizing head of hollow fills spaced 1,000 to 1,500 feet apart and with a highwall averaging 55 feet. No spoil was placed more than 125 feet downslope from the cropline. The head of hollow fills are constructed with a rock lining and have 5-foot alternate layers of toxic and nontoxic fill. Approximately 20 feet of the highwall remains exposed after final grading, which results in a flat bench void of rocks. Before mining, the site was woodland; after reclamation, the site will be utilized for grazing or farmland. The working schedule is 10 hours per shift, one shift per day, 6 days per week. After backfilling, the site was fertilized, seeded, and mulched using a hydroseeder.

TABLE B-1. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 2 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-conventional	1,000	100	330	33	530	53	186	-	0.19

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	285 hp...	2	3.0	3.25	5.40	21.55	3.63	12.07	91.80	275.40	-	-	-
Front-end loader....	6 cu yd..	1	3.0	4.67	5.40	26.77	2.86	9.53	49.23	147.69	-	-	-
									141.03	423.09	3,723	0.34	3.72

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, hydroseeder.......	20	60	60	-	140	70	330	-	0.33
Total reclamation costs..							4,239	0.34	4.24

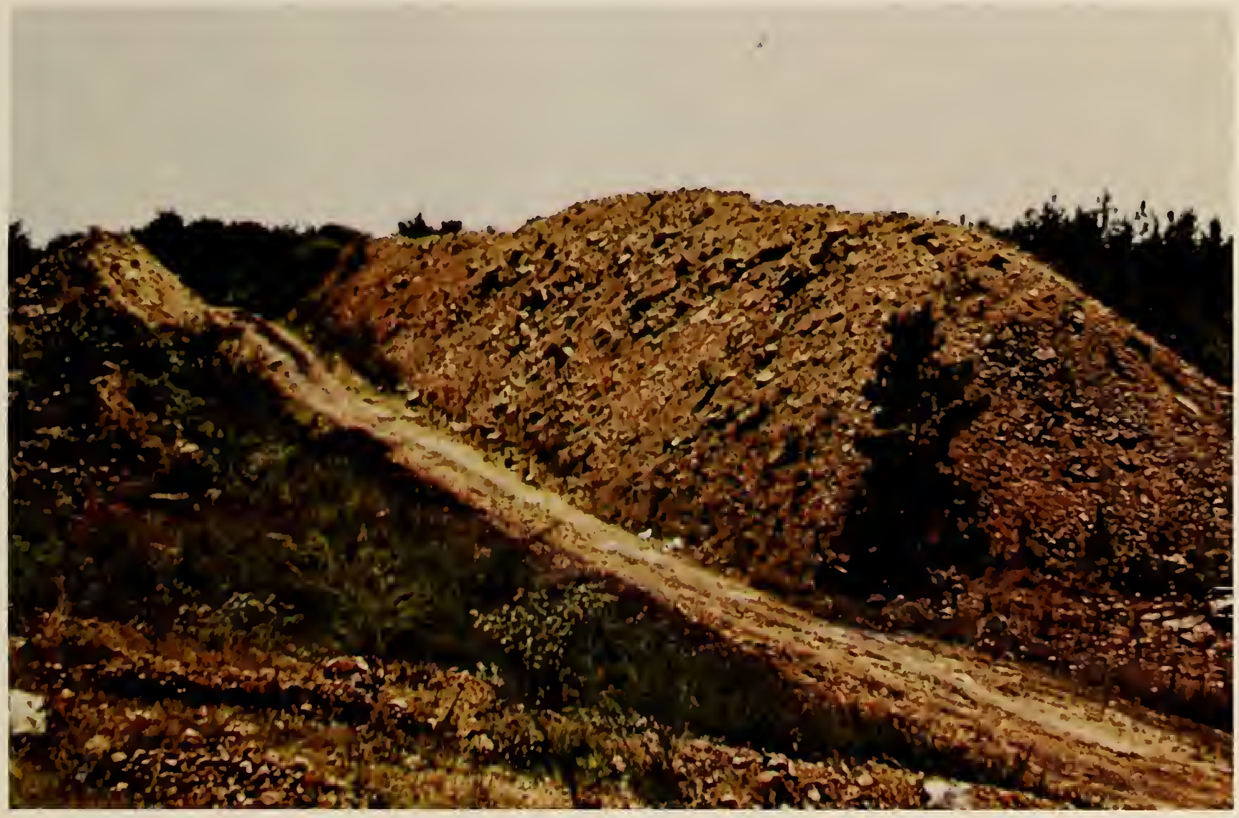

FIGURE B-1. - Mined land that is unreclaimed—the land has been abandoned after removal of the coal.

The estimated cost breakdown in dollars per acre for reclamation from table B-2 is as follows: Premining--$508, backfilling--$7,396, and revegetation--$320. The total cost of reclamation was estimated to be $8,224 per acre affected, $0.31 per cubic yard of overburden, or $4.74 per ton of coal mined.

TABLE B-2. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 3 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-scraper haulback..........	6,300	53	48,000	400	6,600	55	508	-	0.29

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	385 hp...	4	2.0	4.39	5.47	28.19	4.78	15.88	234.84	469.68	-	-	-
Do..............	270 hp...	4	2.0	3.08	5.47	15.80	2.40	7.99	138.96	277.92	-	-	-
Scraper............	21-30 cu yd.	4	9.0	4.73	5.47	34.08	4.47	12.66	245.64	2,210.76	-	-	-
									619.44	2,958.36	7,396	0.31	4.27

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder........	20	60	50	-	120	90	320	-	0.18
Total reclamation costs..							8,224	0.31	4.74

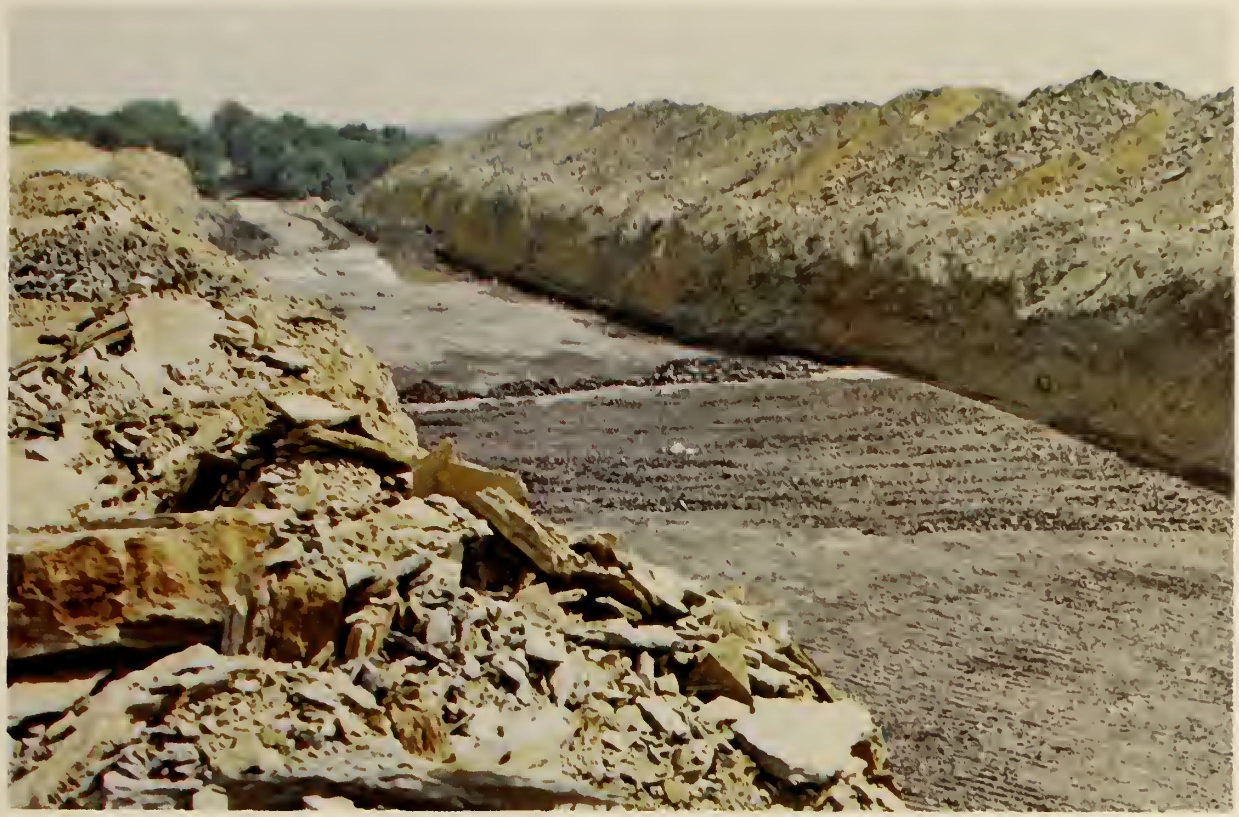

FIGURE B-2. - Area mining pit prior to coal removal and reclamation.

Region I, Site 4

Contour mining that affects 10 acres annually is being conducted on an area with an average slope of 25°. The overburden is gray shale and sandstone with the coalbed thickness averaging 1.6 feet and yielding 14,115 tons of coal.

This is an experimental block cut with head of hollow fill mining operation under Federal contract on a cost-plus basis and backfilled to original contour. A bulldozer and a front-end loader are used in this operation in which the highwall averages 55 feet and the first cut is being deposited in a head of hollow fill. Before mining, the site was woodland; after reclamation, the land will be used for grazing. Revegetation is performed using a hydroseeder that fertilizes, seeds, and mulches. The working schedule is 10 hours per shift, two shifts per day, 5 days per week.

The estimated cost breakdown in dollars per acre for reclamation from table B-3 is as follows: Premining--$375, backfilling--$11,136, and revegetation--$420. The total cost of reclamation was estimated to be $11,931 per acre, $0.69 per cubic yard of overburden, or $11.27 per ton of coal mined. The high cost per ton of coal mined can be attributed to the thin coal seam, the inexperience of operator with block cut stripping method, and the relatively high rainfall in this area.

TABLE B-3. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 4 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-block cut with head of hollow fill..............	2,500	250	5,000	50	750	75	375	-	0.35

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer...............	385 hp...	1	4.0	4.39	5.10	28.19	4.78	15.88	58.34	233.36	-	-	-
Front-end loader....	10 cu yd.	1	4.0	7.06	5.10	58.82	5.92	19.43	96.33	385.32	-	-	-
									154.67	618.68	11,136	0.69	10.52

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	100	-	180	80	420	-	0.40
Total reclamation costs..							11,931	0.69	11.27

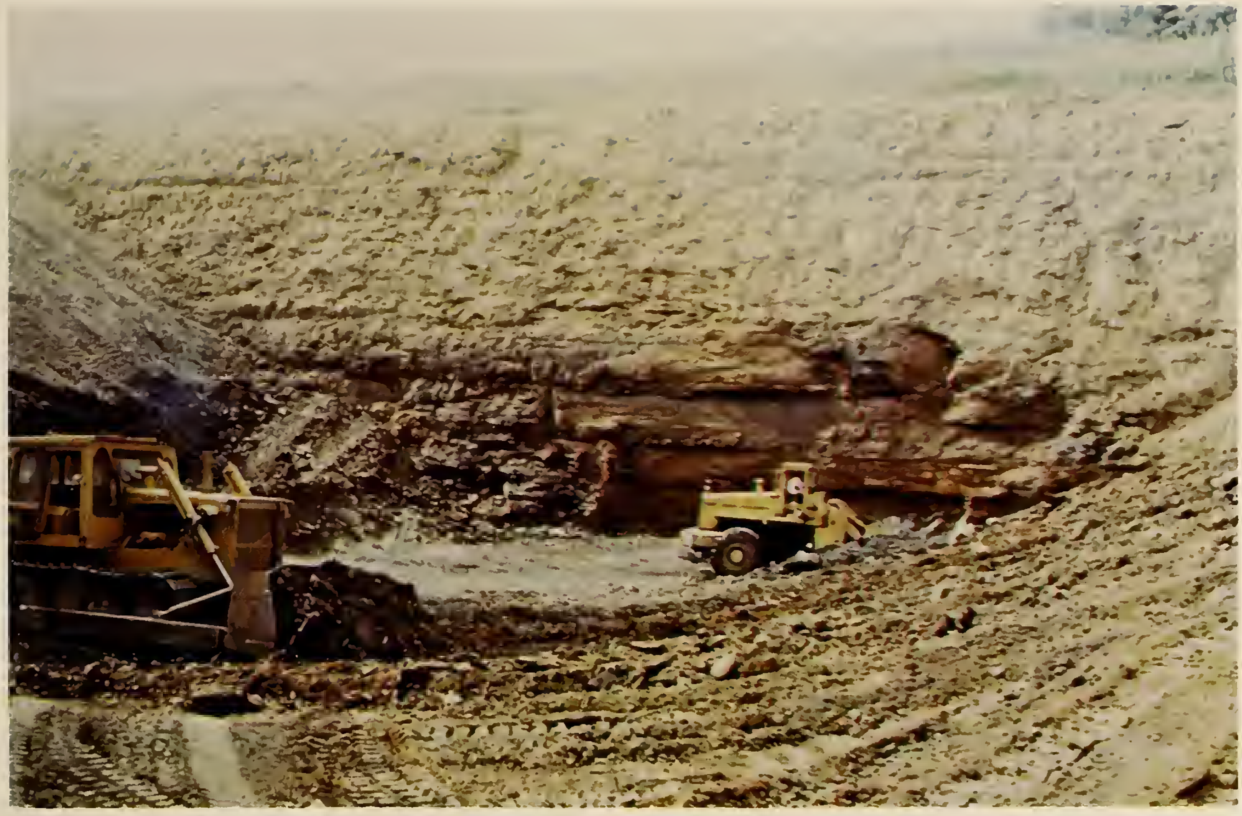

FIGURE B-3. - Contour mining—block stripping.

Region I, Site 5

The contour mining of three coalbeds affects 180 acres of land that has an average slope of 25°. The overburden is gray shale and sandstone with the cumulative coalbed thickness averaging 4.5 feet and yielding 543,369 tons of coal annually.

This is an experimental mining operation under Federal contract on a cost-plus basis and backfilled to the original contour. The combination block cut and truck haulback methods being used consists of backfilling to the original contour with the excess material being hauled by truck to permanent offsite disposal areas. The average truck haulage distance ranges from 1,700 to 2,100 feet. The cumulative highwall height averages 48 feet. Augering is incorporated into the mining sequence whenever possible. Before mining, the site was woodland; after reclamation, the land will be suitable for grazing. The working schedule is 10 hours per shift, two shifts per day, 5 days per week. Revegetation is accomplished by a hydroseeder that fertilizes, seeds, and mulches.

The estimated cost breakdown in dollars per acre for reclamation from table B-4 is as follows: Premining--$325, backfilling--$14,317, and revegetation--$430. The total cost of reclamation was estimated to be $15,072 per acre, $0.32 per cubic yard of overburden, or $3.32 per ton of coal mined.

TABLE B-4. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 5 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-block cut, truck haulback, and head of hollow fill	34,200	190	10,800	60	13,500	75	325	-	0.07

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Front-end loader....	10 cu yd.	2	6.0	7.06	5.10	58.82	5.92	19.34	192.48	1,154,88	-	-	-
Dozer..............	385 hp...	4	6.0	4.39	5.10	28.19	4.78	15.88	233.36	1,400.16	-	-	-
Rear dump trucks....	50 cu yd.	4	18.0	4.32	5.10	33.42	4.78	10.35	231.88	4,173.84	-	-	-
									657.72	6,728.88	14,317	0.32	3.16

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	100	-	180	90	430	-	0.09
Total reclamation costs..							15,072	0.32	3.32

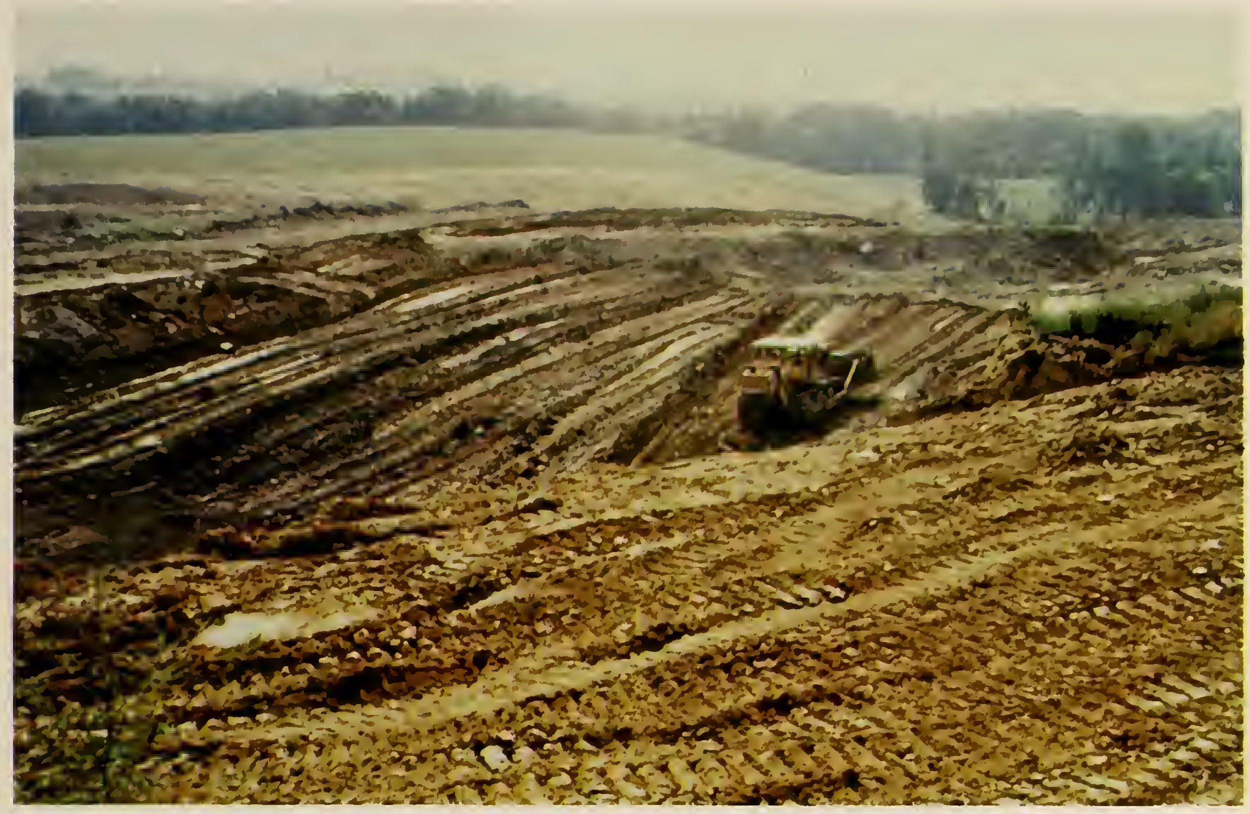

FIGURE B-4. - Backfilling of an area mining pit.

Region I, Site 6

This contour mining operation is being conducted in terrain with an average slope of 25° and affects 120 acres. The overburden is gray shale and sandstone with the coalbed thickness averaging 2.5 feet and yielding approximately 250,000 tons of coal annually.

Mining combines a dragline and a shovel with truck haulback techniques. The resulting highwall averages 50 feet in height. No spoil was placed more than 125 feet downslope from the cropline. Approximately 20 feet of the highwall remains exposed with the resulting bench graded to gently rolling terrain. Before mining, the site was woodland; after reclamation, the site will be utilized for grazing. The working schedule is 10 hours per day, two shifts per day, 6 days per week. Only the dragline, trucks, and front-end loaders work the second shift. Revegetation involves fertilizing, seeding, and mulching with a hydroseeder.

The estimated cost breakdown in dollars per acre for reclamation from table B-5 is as follows: Premining--$167, backfilling--$11,994, and revegetation--$320. The total cost of reclamation was estimated to be $12,481 per acre affected, $0.37 per cubic yard of overburden, or $5.99 per ton of coal mined. The choice of mining equipment does not appear to be suited to the topography of the site. The dragline and shovel have difficulty with mobility because of space limitations and are forced to handle the same overburden more than once. In addition, the operator has implied that he is losing money partially as the result of being prevented by a court order from selling any of his equipment.

TABLE B-5. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 6 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-conventional and truck haulback with dragline and shovel............	6,000	50	7,800	65	6,240	52	167	-	0.08

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	385 hp...	4	4.0	4.39	5.47	28.19	4.78	15.88	234.84	939.36	-	-	-
Front-end loader....	10 cu yd.	2	4.0	7.06	5.47	58.82	5.92	19.43	193.40	773.60	-	-	-
Dragline...........	Small....	1	4.0	8.74	10.50	132.83	11.86	36.60	200.53	802.12	-	-	-
Shovel.............	...do....	1	2.0	10.51	10.50	113.94	12.43	29.88	177.26	354.52	-	-	-
Rear dump trucks....	50 cu yd.	2	18.0	4.32	5.47	33.42	4.78	10.35	116.68	2,100.24	-	-	-
									922.71	4,969.84	11,994	0.37	5.76

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	60	-	110	90	320	-	0.15
Total reclamation costs..........							12,481	0.37	5.99

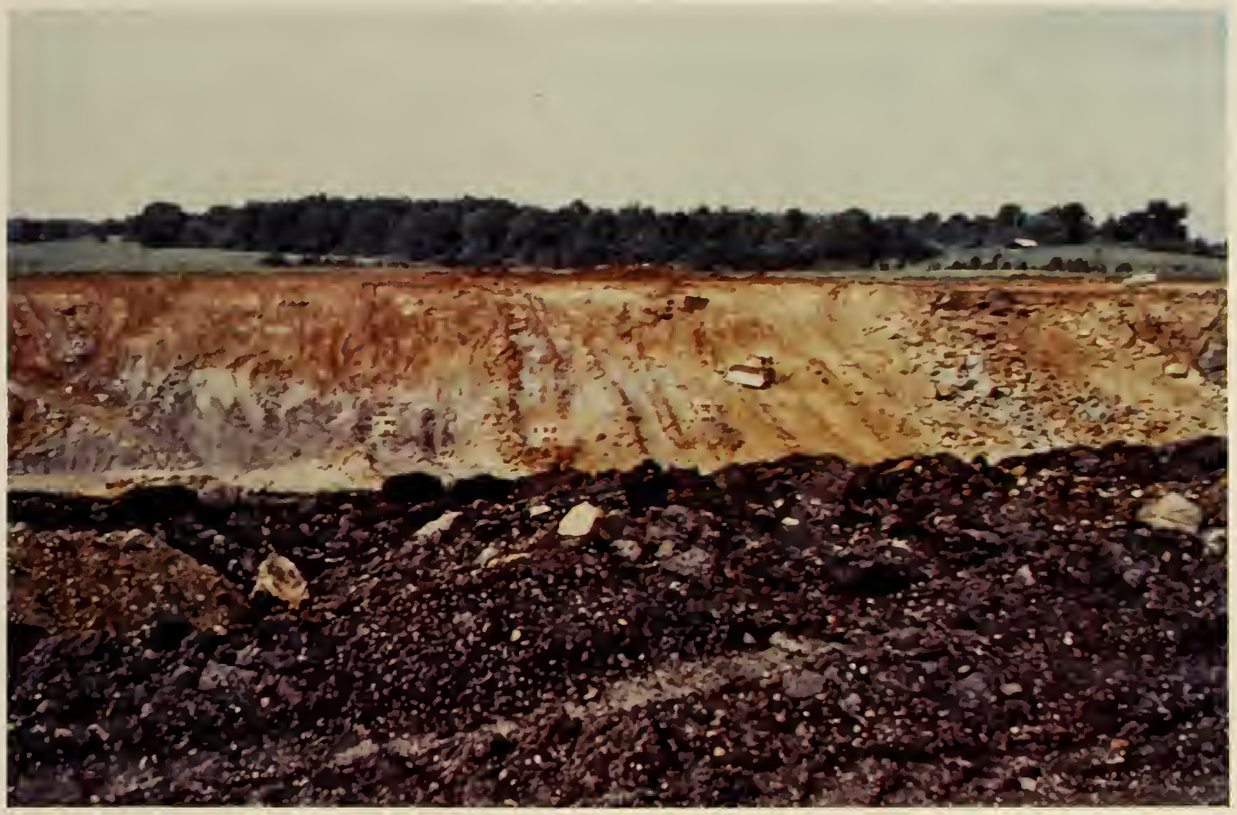

FIGURE B-5. - Stripping and backfilling adjacent pits utilizing bulldozers.

Region I, Site 7

Area-type mining utilizing a medium size stripping shovel is being done on a gently rolling plateau with an average slope of 10° affecting 90 acres each year. Approximately 250,000 tons of coal are produced annually from one seam averaging 2.2 feet in thickness, which is overlain by an average of 50 feet of overburden composed primarily of clay, sandstone, and shale.

The stripping shovel is scheduled to operate three 8-hour shifts per day, 350 days per year. Backfilling and grading is done in a single 8-hour shift, 250 days per year. Reclamation results in gently rolling terrain revegetated with pine trees and grasses. Revegetation is accomplished utilizing a helicopter-mounted hydroseeder available on a contract basis. Mulch, fertilizer, and lime are not used in significant quantities at the present time. The ponds produced as a result of reclamation are stocked with fresh-water game fish; this cost is included in the cost of revegetation. The land use prior to mining was pine forest; after mining, the land will be returned to pine forest.

The estimated cost per acre of each phase of reclamation as shown in table B-6 is premining--$131, backfilling--$2,625, and revegetation--$74. The estimated total cost of reclamation is $2,830 per acre of affected land, $0.13 per cubic yard of material moved during backfilling and grading, or $1.02 per ton of coal produced.

TABLE B-6. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 7 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area................	5,400	60	5,981	66	450	5	131	-	0.05

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Shovel.............	Medium...	1	4.0	17.84	14.00	42.82	48.75	(1)	123.41	493.64	-	-	-
Dozer, D-8.........	270 hp...	1	7.0	3.08	7.00	15.80	2.40	7.99	36.27	253.89	-	-	-
									(2)	(2)	2,625	0.13	0.94

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	-	[3]43	-	-	-	31	74	-	0.03
Total reclamation costs..							2,830	0.13	1.02

[1] Completely depreciated.

[2] These forms are not totaled because different pieces of equipment operate a different number of days each year.

[3] Includes restocking ponds with fish.

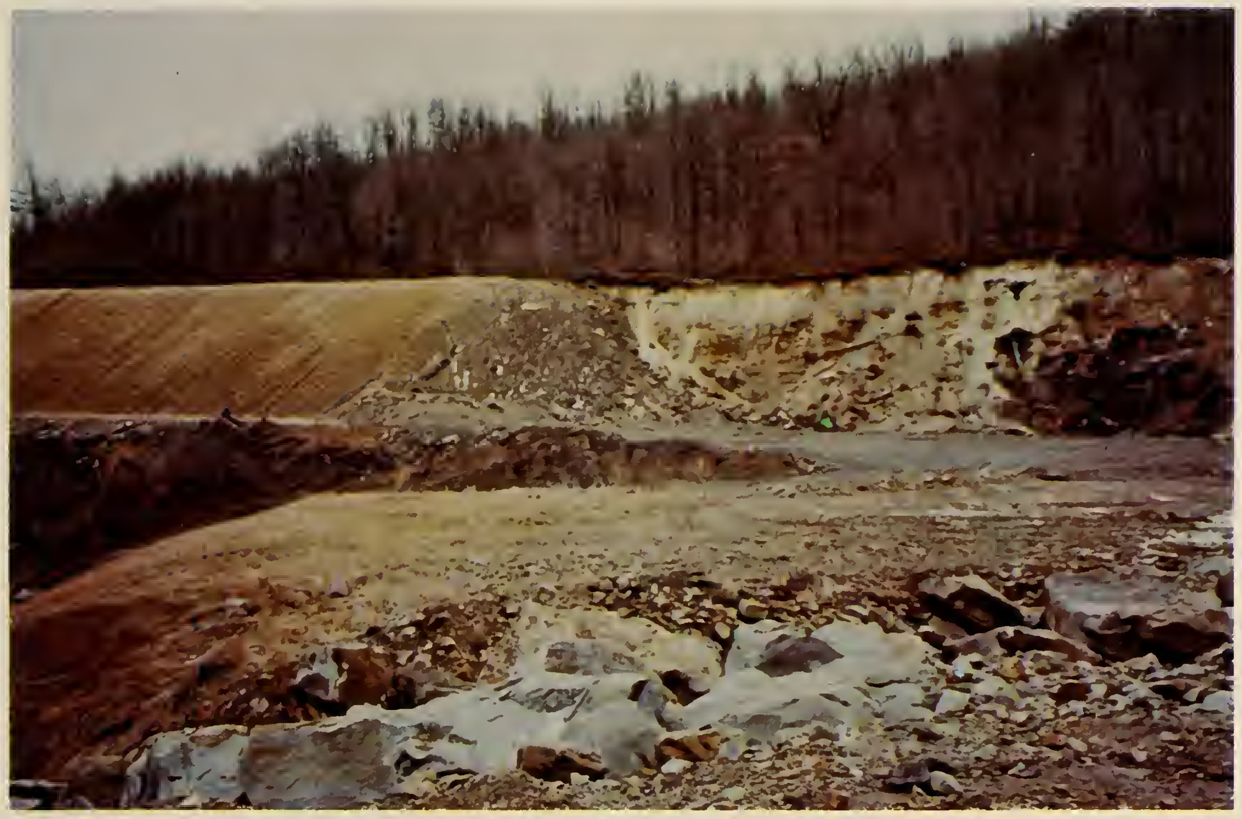

FIGURE B-6. - Contour pit prior to backfilling (right), after backfilling (left).

Region I, Site 8

Area-type mining takes place on gently rolling terrain with an average slope of 10°. Approximately 40 acres of land are affected annually involving the production of 250,000 tons of coal. Two coal seams with a cumulative average thickness of 5 feet are overlain by an average of 70 feet of overburden consisting of shale, limestone, and clay.

The equipment, which splits working time between mining and reclamation, is scheduled to operate one 10-hour shift per day, 200 days per year. Reclamation returns the land to the approximate original contour, involves topsoil movement and storage, and provides revegetation with trees, grasses, and legumes. The revegetation process utilizes a farm tractor, disk, fertilizer and lime spreader, tree planting by hand, a mulcher, and a helicopter-mounted hydroseeder. Reclamation returns mined land to its previous use as woodland and pasture.

The estimated cost per acre for each phase of reclamation as shown in table B-7 is premining--$257, backfilling--$7,872, and revegetation--$335. The total cost of reclamation amounts to $8,464 per acre, $1.35 per ton of coal mined, and $0.20 per cubic yard of material moved during backfilling, grading, and topsoil movement.

TABLE B-7. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 8 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area	3,440	86	6,160	154	680	17	257	-	0.04

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer	385 hp	6	2.5	4.39	6.00	28.19	4.78	15.88	355.44	888.60	-	-	-
Wheel loader	8.875 cu yd.	2	2.5	8.61	6.00	40.52	4.08	13.59	145.60	364.00	-	-	-
Do	10 cu yd.	1	2.5	7.81	6.00	50.00	4.92	16.40	85.13	212.83	-	-	-
Do	7 cu yd.	1	2.5	4.67	6.00	22.73	2.36	7.86	43.62	109.05	-	-	-
									629.79	1,574.48	7,872	0.20	1.26

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder, farm tractor, disk, lime spreader, mulcher	-	164	54	23	60	34	335	-	0.05
Total reclamation costs							8,464	0.20	1.35

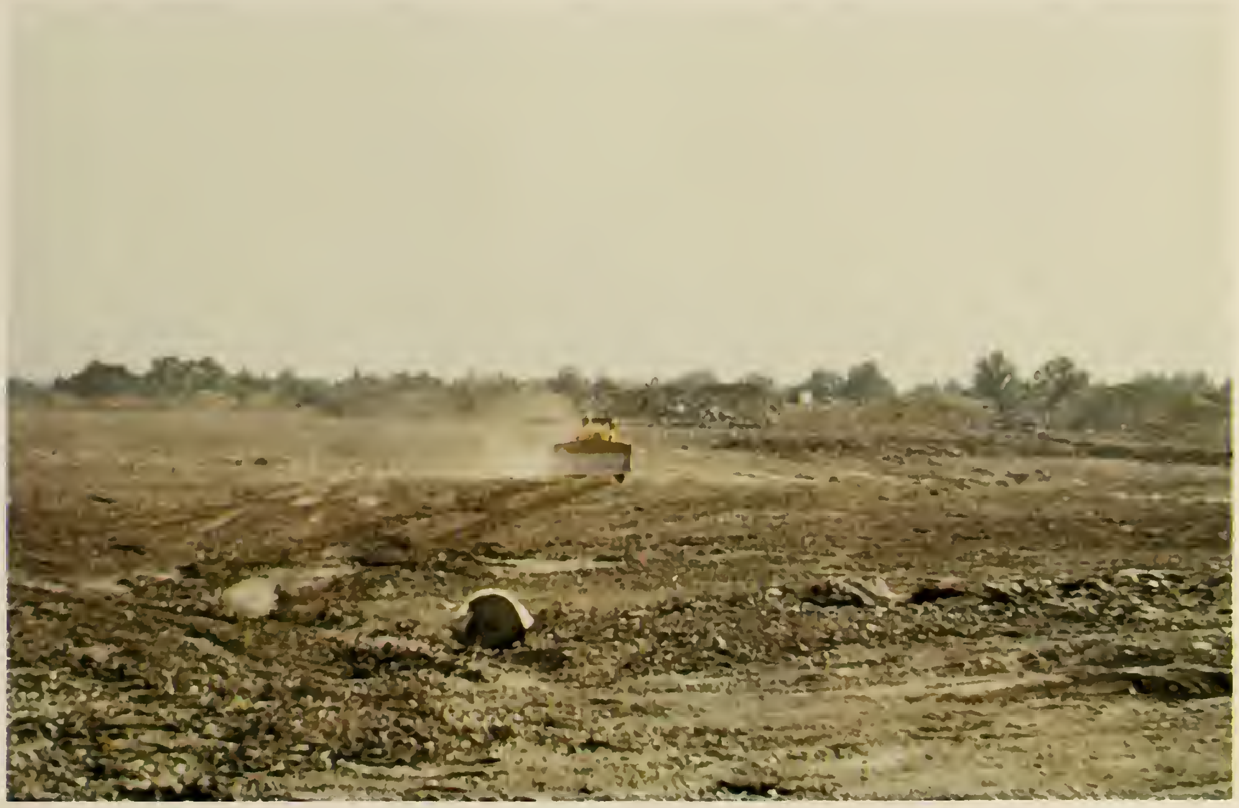

FIGURE B-7. - Backfilling and grading of a pit mined by area mining.

Region I, Site 9

Area-type mining affects 360 acres annually in order to produce 1.28 million tons of coal. The coal seam averages 2.5 feet in thickness and is overlain by an average of 50 feet of overburden. The terrain at the mine site has an average slope of 10°.

The stripping equipment is scheduled to operate three 8-hour shifts per day, 350 days per year; all other equipment is scheduled to operate three 8-hour shifts per day, 243 days per year. Reclamation results in backfilling to a gently rolling topography and revegetation with pine trees and grasses. The land prior to and after mining consists primarily of pine woods and pasture. Revegetation is performed on a contract basis utilizing a helicopter-mounted hydroseeder immediately after the completion of final grading.

The estimated cost per acre for each phase of reclamation as shown in table B-8 is premining--$444, backfilling--$6,838, and revegetation--$47. The total cost of reclamation amounts to $7,329 per acre, $2.06 per ton of coal produced, and $0.26 per cubic yard of material moved during backfilling and grading.

TABLE B-8. - Estimated reclamation premining planning, backfilling, and revegetation costs for region I, site 9 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area	21,600	60	136,440	379	1,800	5	444	-	0.13

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer	385 hp	2	20.0	4.39	6.12	28.19	28.19	15.88	118.72	2,374.40	-	-	-
Do	285 hp	1	20.0	3.25	6.12	21.55	21.55	12.07	46.62	932.40	-	-	-
Scraper	20 cu yd.	3	20.0	3.65	6.12	16.84	16.84	6.08	104.52	2,090.20	-	-	-
Shovel	Large	1	4.0	72.61	75.91	256.47	277.88	138.94	821.81	3,287.00	-	-	-
									(1)	(1)	6,838	0.26	1.92

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder	-	18	-	21	-	8	47	-	0.01
Total reclamation costs							7,329	0.26	2.06

[1] These columns are not totaled because different pieces of equipment operate a different number of days each year.

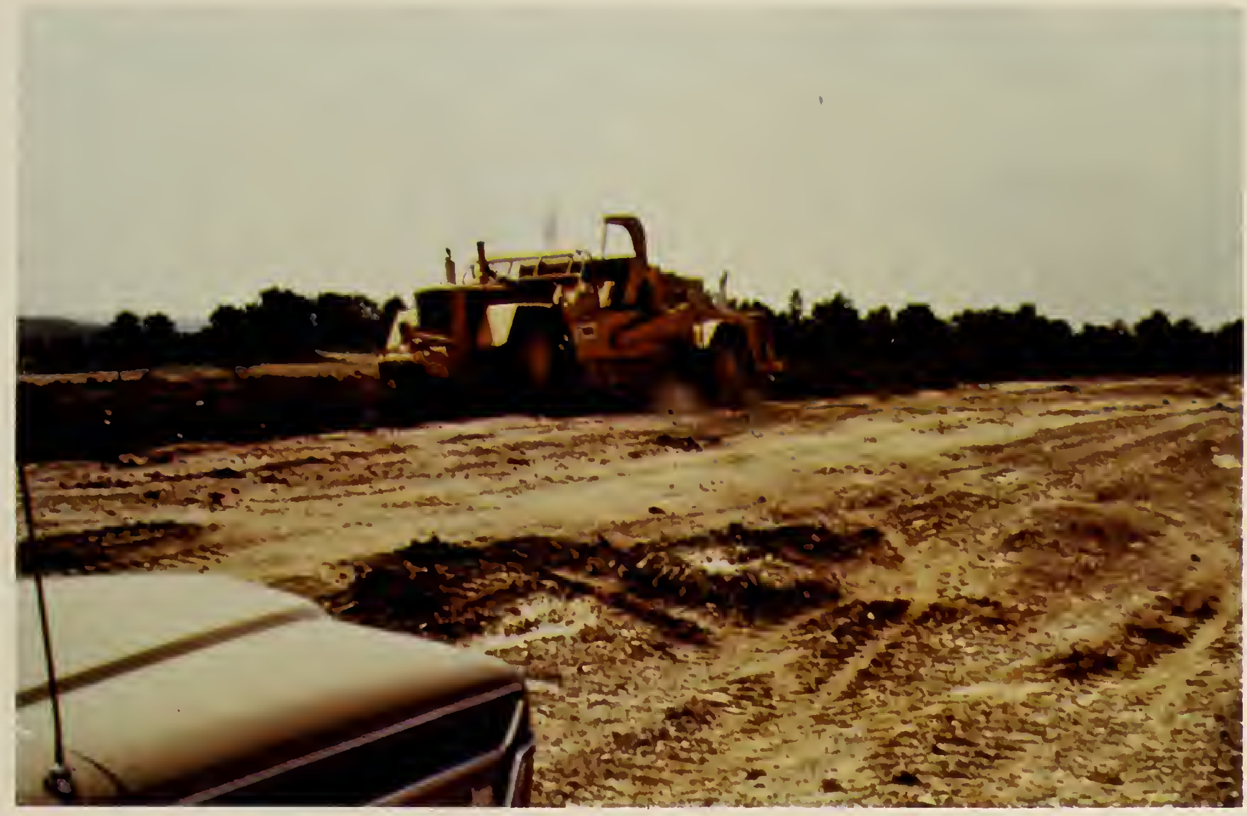

FIGURE B-8. - Topsoil replacement after backfilling and grading.

Region II, Site 2

Contour mining, conducted in an area with an average slope of 25°, affects 90 acres. The overburden is gray shale and sandstone with the coalbed thickness averaging 3 feet and yielding approximately 180,000 tons of coal annually.

Block cut and truck haulback with head of hollow fill techniques are utilized in conjunction with augering. The highwall averages 50 feet in height and is backfilled to the original contour. The access roads are sloped in a manner that facilitates runoff, channeling the water through the spoil to a pond below the spoil banks. Before mining, the site was woodland, and after reclamation, it will be used for grazing and farming. The working schedule is 9 hours per shift, one shift per day, 6 days per week. Revegetation consists of fertilizing seeding, and mulching using the hydroseeder. Certain areas require seeding more than once.

The estimated cost breakdown in dollars per acre for reclamation from table B-9 is as follows: Premining--$205, backfilling--$7,510, and revegetation--$335. The total cost for reclamation was estimated to be $8,050 per acre, $0.31 per cubic yard backfilled, or $4.02 per ton of coal mined.

TABLE B-9. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 2 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-block cut with truck haulback	5,850	65	4,500	50	8,100	90	205	-	0.10

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer...............	385 hp...	2	2.7	4.39	7.55	28.19	4.78	15.88	121.58	328.27	-	-	-
Do................	270 hp...	1	2.7	3.08	7.55	15.80	2.40	7.99	36.82	99.41	-	-	-
Front-end loader....	10 cu yd.	1	2.7	7.81	7.55	50.00	4.92	16.40	86.68	234.04	-	-	-
Do................	10 cu yd.	1	2.7	7.06	7.55	58.82	5.92	19.43	98.78	266.11	-	-	-
Rear dump trucks....	50 cu yd.	3	8.1	4.57	7.55	31.52	4.44	9.62	173.10	1,402.11	-	-	-
									516.96	2,330.54	7,510	0.31	3.75

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	65	-	100	110	335	-	0.17
Total reclamation costs....................							8,050	0.31	4.02

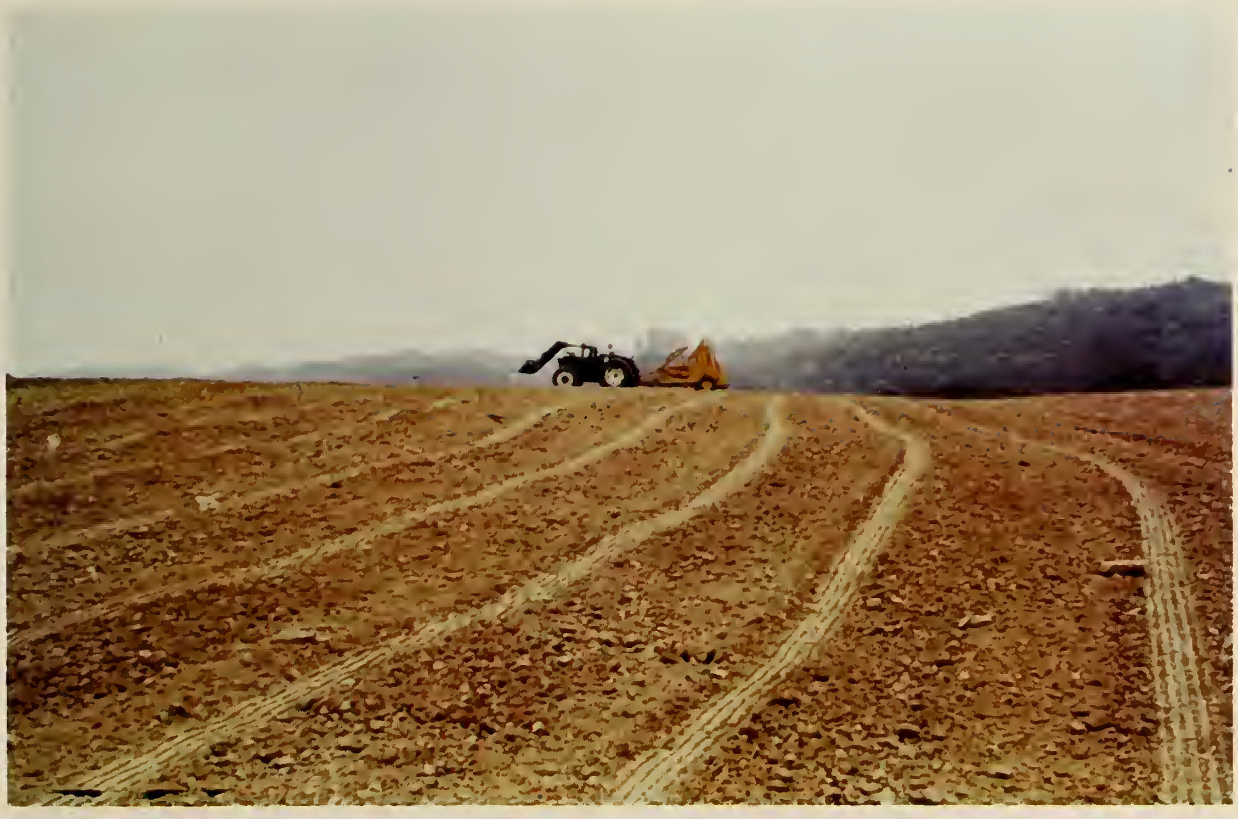

FIGURE B-9. - Reclamation prior to revegetation but after backfilling, grading, and topsoil replacement.

Region II, Site 3

Contour mining, which is being conducted on terrain with an average slope of 20°, affects 6 acres. The overburden is gray shale and sandstone with the cumulative coalbed (two) thickness averaging 3.2 feet and yielding approximately 15,000 tons of coal annually.

A single bulldozer is utilized to move and place overburden in addition to gathering and stockpiling the topsoil. Stripping results in a cut with a highwall averaging 40 feet in height, which is backfilled to the original contour. The operation proceeds in only one direction from the initial block cut. To minimize the amount of spoil disturbed in the critical first cut, a portion of the hillside containing a swale was chosen for the initial block cut. The block cut averaged about 150 feet wide (low wall to highwall) with an average length of 175 feet. Before mining, the site was woodland; after reclamation, the site will be used for grazing. The working schedule is 10 hours per day, one shift per day, 6 days per week. Revegetation that includes fertilizing, seeding, and mulching is accomplished using a hydroseeder.

The estimated cost breakdown in dollars per acre for reclamation from table B-10 is as follows: Premining--$200, backfilling--$6,163, and revegetation--$370. The total cost of reclamation was estimated to be $6,733 per acre, $0.19 per cubic yard of overburden, or $2.70 per ton of coal mined. The dozer operator has the reputation of possessing a great deal of expertise in block cut mining, which is reflected by the low cost per cubic yard.

TABLE B-10. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 3 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-block cut...	350	70	360	80	350	50	200	-	0.08

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	273 hp..	1	3.0	3.21	6.00	17.87	2.84	11.17	41.09	123.27	-	-	-
									41.09	123.27	6,163	0.19	2.47

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Hydroseeder.........	20	60	90	40	100	80	370	-	0.15
Total reclamation costs..							6,733	0.19	2.70

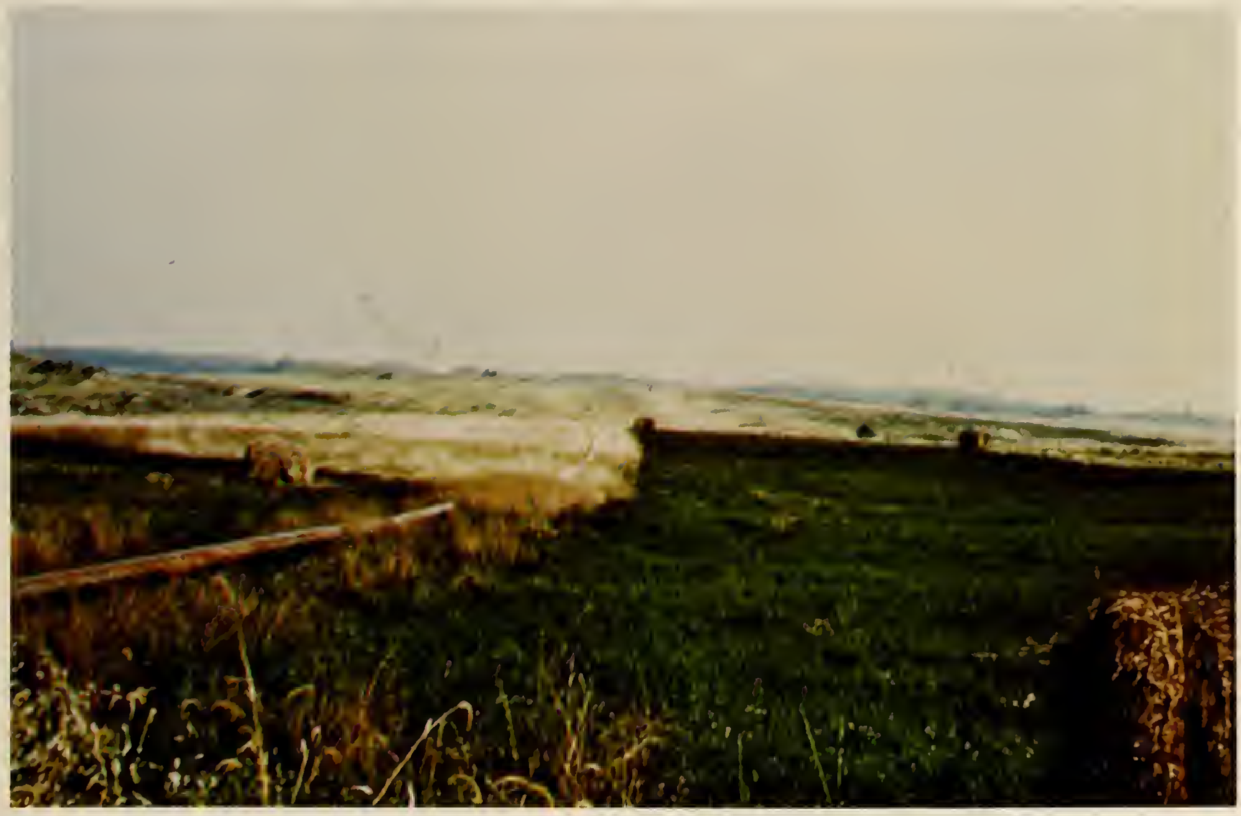

FIGURE B-10. - Agricultural activities on reclaimed land with area mining in the background.

Region II, Site 4

Mining operations affect approximately 12 acres of land annually yielding 45,000 tons of coal from one coalbed averaging 3 feet in thickness. The coal is overlain by an average of 50 feet of overburden composed primarily of sandstone, limestone, and clay.

The average slope of the site is 15°, and the mining is done by the block stripping method. Operations are scheduled for two 9-hour shifts per day, 230 days per year. Reclamation results in a return of the land to its approximate original contour and revegetation with grasses and legumes. Revegetation, which is done on a contract basis, involved disking, spreading lime and fertilizer, and seeding, utilizing a farm tractor, disk, and a hydroseeder. Mined land is returned to its previous use as pasture.

The estimated cost per acre for each phase of reclamation, as shown in table B-11, is premining--$173, backfilling--$11,996, and revegetation--$100. The total cost of reclamation is $12,269 per acre, $3.28 per ton of coal mined, and $0.37 per cubic yard of material moved during backfilling, grading, and topsoil movement.

TABLE B-11. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 4 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour-block cut...	150	13	1,650	138	264	22	173	-	0.05

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer, D-9..........	-	1	4.0	4.39	6.00	28.19	4.78	15.88	59.24	236.96	-	-	-
Wheel loader, cat 992	10 cu yd.	1	4.0	7.06	6.00	58.82	5.92	19.43	97.23	388.92	-	-	-
									156.47	625.88	11,996	0.37	3.20

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, hydroseeder........	20	50	19	11	-	20	100	-	0.03
Total reclamation costs..							12,269	0.37	3.28

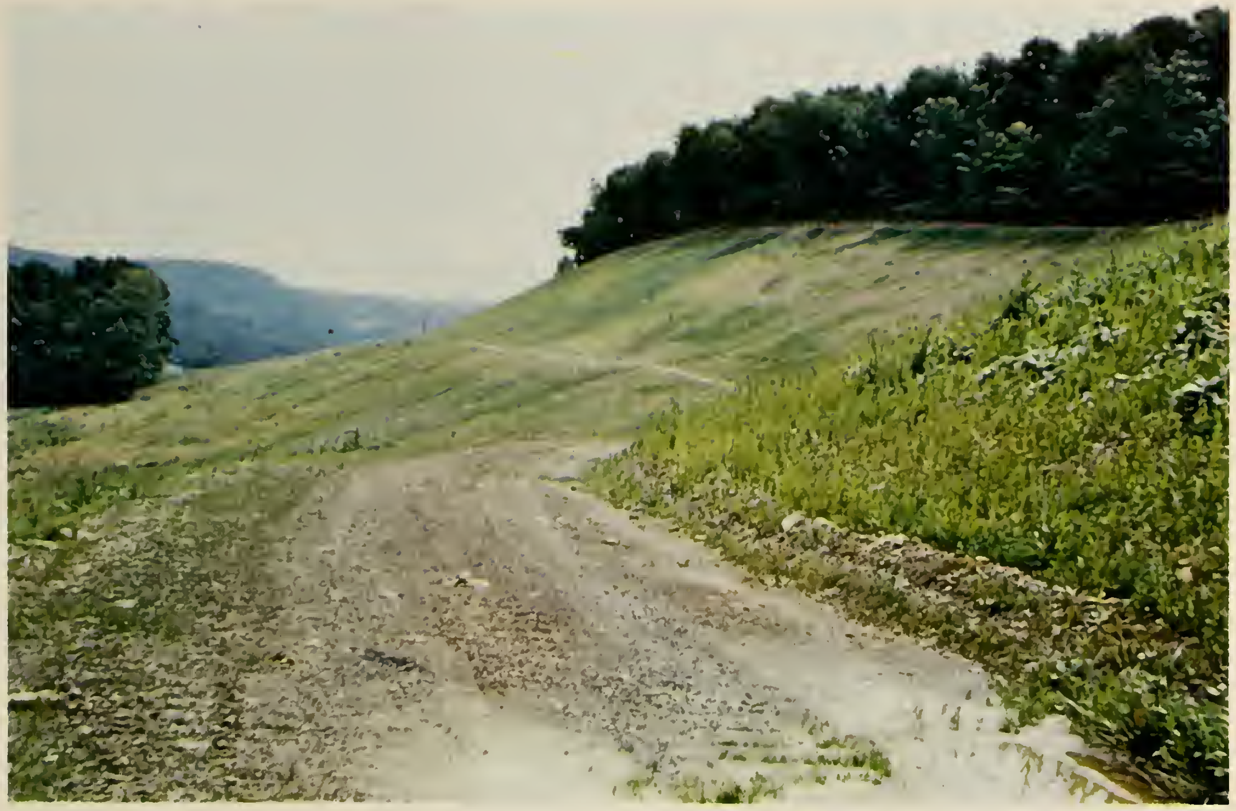

FIGURE B-11. - Reclaimed contour mining site with terrace.

Region II, Site 5

Area mining is being conducted on the floor of a valley that has an average slope of 10°. Approximately 29 acres are affected annually to produce 108,000 tons of coal. The coalbed averages 3.5 feet in thickness and is overlain by an average of 50 feet of overburden composed primarily of shale and slate.

Stripping operations utilize a small dragline, which is scheduled to operate three 8-hour shifts per day, 250 days per year. Backfilling and grading equipment is scheduled to operate one 10-hour shift per day, 250 days per year, with time split between reclamation and mining. Topsoil replacement is completed during a 3-week period in which a wheel-loader, truck, and a small dozer are schedule to operate one 10-hour shift per day. Reclamation provides for backfilling to the approximate original contour and revegetation with grasses and legumes. Revegetation equipment include farm tractors, disks, and a mulcher. Mined land is returned to its previous state as pasture and woodland.

The estimated cost per acre of each phase of reclamation as shown in table B-12 is premining--$188, backfilling--$7,990, and revegetation--$288. The total costs of reclamation are $8,406 per acre, $2.26 per ton of coal produced, and $0.25 per cubic yard of material moved during backfilling, grading, and topsoil movement.

TABLE B-12. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 5 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area	1,000	50	2,000	100	750	38	188	-	0.05

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer	270 hp	1	5.0	3.08	5.00	15.80	2.40	7.99	34.27	171.35	-	-	-
Wheel-loader	8.875 cu yd	1	9.0	8.61	5.00	40.52	4.08	13.59	71.80	[1]646.20	-	-	-
Truck	35 cu yd	2	9.0	3.12	5.00	22.42	3.20	6.94	81.36	[1]732.24	-	-	-
Dozer	140 hp	1	9.0	1.60	5.00	10.40	1.58	5.26	23.84	[1]214.56	-	-	-
Dragline	Small	1	4.0	8.74	10.50	127.93	11.88	5.94	164.99	659.96	-	-	-
									(2)	(2)	7,990	0.25	2.15

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, mulcher	32	56	22	20	100	30	228	-	0.06
Total reclamation costs							8,406	0.25	2.26

[1] 3 weeks per year.

[2] These columns are not totaled because different pieces of equipment operate a different number of days each year.

Region II, Site 6

Area mining, which affects approximately 100 acres annually, is conducted on gently sloping terrain with an average slope of 8°. Coal production amounting to 400,000 tons each year is obtained from three coalbeds with an average cumulative thickness of 6 feet. The overburden averages 75 feet in thickness and is composed primarily of shale, clay, and sandstone.

Mining operations are scheduled for three 8-hour shifts per day, 304 days per year. Reclamation involves a return to the approximate original contour and revegetation with grasses and legumes. Prior to mining, the land is used as pasture; after reclamation, the land is returned to use as pasture. The revegetation process involves the use of a farm tractor, a disk, a fertilizer truck, and a broadcast seeder.

The estimated cost per acre of each phase of reclamation, as shown in table B-13, is premining--$168, backfilling--$7,831, and revegetation--$269. The total cost of reclamation is $8,286 per acre, $2.07 per ton of coal produced, and $0.18 per cubic yard of material moved during backfilling, grading, and topsoil movement.

Region III, Site 2

Contour mining is conducted in terrain consisting of rolling hills with an average slope of 15°. A coalbed averaging 4 feet in thickness, overlain by an average of 70 feet of clay, shale, and limestone, yields 650,000 tons of coal annually. An average of 460 acres of land is affected each year.

A medium-size shovel is utilized to remove overburden on an operating schedule of three 8-hour shifts per day, 350 days per year. Equipment utilized for backfilling, grading, and topsoil movement is scheduled to operate three 8-hour shifts per day, 250 days per year. Reclamation involves 100 percent backfilling with the top section of the highwall removed utilizing explosives, followed by final grading. Revegetation involves disking, liming, fertilizing, mulching, and seeding with grasses, legumes, and trees. Mined land is returned to its prior use as pasture.

The estimated cost per acre of each phase of reclamation, as shown in table B-14, is premining--$165, backfilling--$5,353 (including the cost of blasting the top section of the highwall), and revegetation--$388. The total cost of reclamation is estimated to be $5,906 per acre of affected land reclaimed, $0.21 per cubic yard of material moved during backfilling, grading, and topsoil movement, and $4.17 per ton of coal produced.

TABLE B-13. - Estimated reclamation premining planning, backfilling, and revegetation costs for region II, site 6 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area................	900	9	12,200	122	3,700	37	168	-	0.04

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dragline............	Small...	2	4.0	19.37	12.00	24.59	28.18	[1]0.00	84.14	673.12	-	-	-
Dozer...............	385 hp..	2	10.0	4.39	6.00	28.19	4.78	15.88	59.24	1,184.80	-	-	-
Do..............	270 hp..	1	6.5	3.08	6.00	15.80	2.40	7.99	35.27	229.26	-	-	-
Scraper.............	32 cu yd	1	6.5	7.30	6.00	41.06	5.46	15.48	75.30	489.45	-	-	-
									-	2,576.63	7,831	0.18	1.96

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, fertilizer truck, seeder............	-	99	113	11	-	46	269	-	0.07
Total reclamation costs..							8,286	0.18	2.07

---

[1]Completely depreciated.

TABLE B-14. - Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 2 (1975)

Mining method	Premining planning costs: Engineering design: Total cost, dollars	Engineering design: Dollars per acre	Antipollution measures: Total cost, dollars	Antipollution measures: Dollars per acre	Bonds, permits, and fees: Total cost, dollars	Bonds, permits, and fees: Dollars per acre	Total premining planning costs: Dollars per acre	Total premining planning costs: Dollars per cubic yard	Total premining planning costs: Dollars per ton
Contour............	39,100	85	22,590	49	14,260	31	165	-	0.12

Equipment	Backfilling equipment--operating and ownership costs: Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars: Fuel	Hourly operating cost, dollars: Labor	Hourly operating cost, dollars: Maintenance	Hourly ownership cost, dollars: Overhead	Hourly ownership cost, dollars: Depreciation	Total operating and ownership costs: Dollars per hour	Total operating and ownership costs: Dollars per day	Total backfilling costs: Dollars per acre	Total backfilling costs: Dollars per cubic yard	Total backfilling costs: Dollars per ton
Dozer, D-9..........	-	2	20.0	4.39	6.00	28.19	4.78	15.88	59.24	2,369.60	-	-	-
Scraper, cat. 657-B.	44 cu yd.	2	20.0	10.83	6.00	57.34	7.44	21.08	102.69	4,107.60	-	-	-
Scraper, cat. 637-B.	32 cu yd.	1	20.0	7.30	6.00	41.06	5.46	15.48	75.30	1,506.00	-	-	-
Shovel.............	Medium...	1	2.0	42.56	18.00	128.47	112.13	(1)	301.16	602.32	-	-	-
Reclamation blasting cost.	-	-	-	-	-	-	-	-	-	-	556	-	0.39
									(2)	(2)	4,797	0.21	3.39

Equipment	Revegetation costs: Equipment operating and ownership costs: Dollars per hour	Equipment operating and ownership costs: Dollars per acre	Soil preparation, dollars per acre: Fertilizer	Soil preparation, dollars per acre: Lime	Soil preparation, dollars per acre: Mulch	Seeding, dollars per acre	Total revegetation costs: Dollars per acre	Total revegetation costs: Dollars per cubic yard	Total revegetation costs: Dollars per ton
Farm tractor, disk, brillion seeder....	30	90	60	11	150	77	388	-	0.27
Total reclamation costs..........							5,906	0.21	4.17

[1] Completely depreciated.

[2] These columns are not totaled because different pieces of equipment operate a different number of days each year.

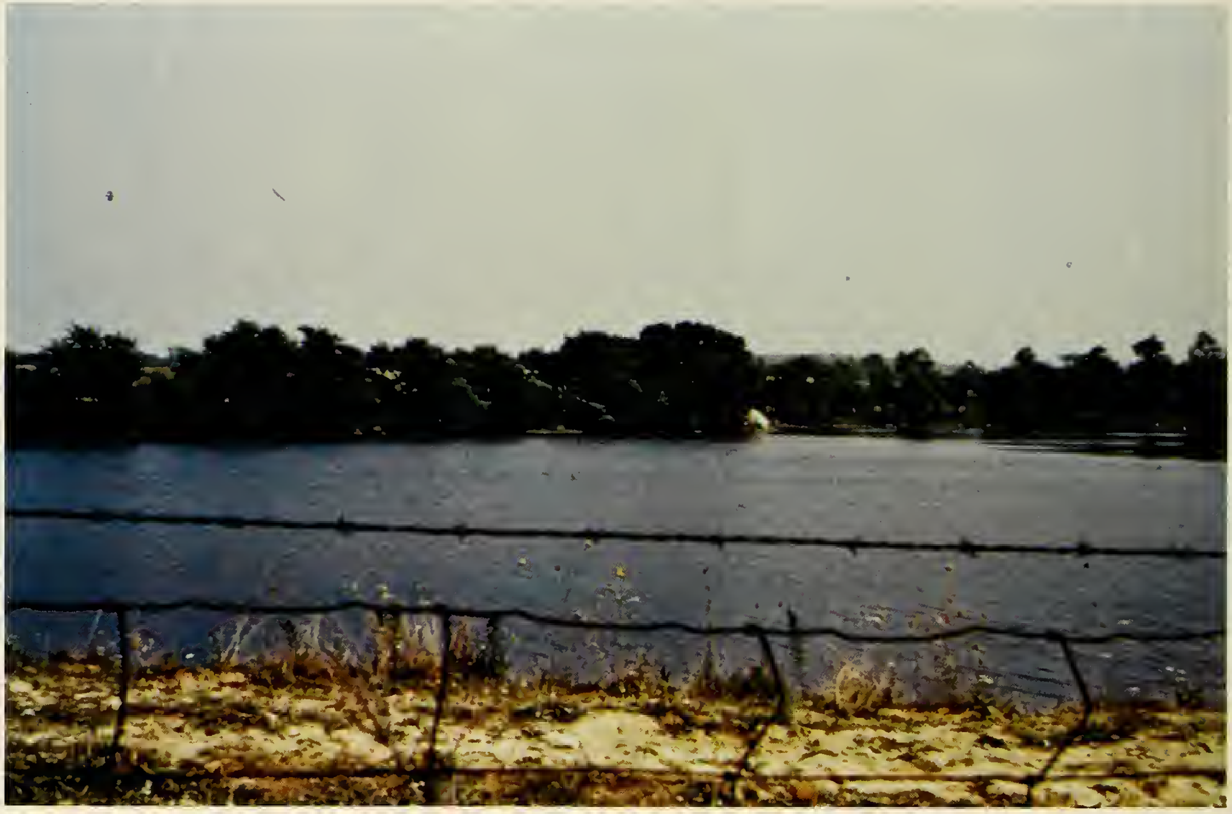

FIGURE B-12. - Reclaimed area mining site.

Region III, Site 3

Area mining on flat terrain with an approximate 5° slope affects approximately 150 acres annually to produce 1.1 million tons of coal. The coalbed averages 7 feet in thickness and is overlain by an average of 100 feet of overburden.

The primary stripping equipment and bulldozers utilized for reclamation are scheduled to operate three 8-hour shifts per day, 300 days per year. A small dragline utilized for reclamation is scheduled to operate one 8-hour shift per day, 300 days per year. Reclamation involves backfilling to the approximate original contour and revegetation with row crops (where suitable), grasses, and legumes. Land use prior to and after mining is for crop production and livestock grazing. Farm tractors and disks are utilized for soil preparation. Seeding is done by a fixed-wing aircraft for grasses and legumes and by a seed drill for row crops.

The estimated cost per acre for each phase of reclamation, as shown in table B-15, is premining--$333, backfilling--$14,206, and revegetation--$111. The total cost of reclamation amounts to $14,650 per acre, $2.01 per ton of coal produced, and $0.23 per cubic yard moved during backfilling and grading.

TABLE B-15. - Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 3 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area	9,000	60	37,500	250	3,450	23	333	-	0.05

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer	385 hp	3	20.0	4.39	6.03	28.19	4.78	15.88	177.81	3,556.20	-	-	-
Dragline	Small	1	6.5	9.71	13.55	11.40	14.59	(1)	49.25	320.13	-	-	-
Do	Large	1	4.0	155.71	20.20	266.00	243.20	121.60	806.71	3,226.84	-	-	-
									-	7,103.17	14,206	0.23	1.94

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractors, disks, seed drill, fixed-wing aircraft	-	75	25	-	-	11	111	-	0.02
Total reclamation costs							14,650	0.23	2.01

[1] Completely depreciated.

Region III, Site 4

Contour mining is conducted at several sites on terrain with average slopes of approximately 17°. Annually, 2,400 acres are affected in order to produce approximately 6 million tons of coal. Two coalbeds are being mined that average 4 feet in thickness and are overlain by an average of 60 feet of overburden.

Mining operations are scheduled for three 8-hour shifts per day, 230 days per year. Reclamation includes 100 percent backfilling and grading, and revegetation with grasses, legumes, and row crops. The revegetation is accomplished through a contractor using farm tractors, disks, and broadcast seeders. Prior to mining, the land is partially wooded pasture; after reclamation, the land is suitable for use as pasture or for producing row crops.

The estimated cost per acre for each phase of reclamation, as shown in table B-16, is premining--$302, backfilling--$9,488, and revegetation--$146. The total cost of reclamation amounts to $9,936 per acre, $3.98 per ton of coal produced, and $0.18 per cubic yard of material moved during backfilling, grading, and topsoil movement.

Region III, Site 5

Area-type mining, which affects approximately 192 acres annually, is being conducted on level terrain with a slope of approximately 5°. Approximately 900,000 tons of coal is produced each year from a coalbed averaging 5 feet in thickness, overlain by an average of 55 feet of overburden.

Stripping operations are scheduled for three 8-hour shifts per day, 350 days per year. Reclamation is scheduled to operate three 8-hour shifts per day, 253 days per year. Reclamation involves 100 percent backfilling and revegetation with grasses and legumes. Revegetation equipment includes farm tractors, disks, and broadcast seeders. After mining, the land is returned to its previous use as pasture.

The estimated cost per acre for each phase of reclamation, as shown by table B-17, is premining--$283, backfilling--$5,354, and revegetation--$119. The total cost of reclamation amounts to $5,756 per acre, $1.23 per ton of coal produced, and $0.16 per cubic yard of material moved during backfilling and grading.

TABLE B-16. - Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 4 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Contour..........	48,000	20	600,000	250	76,800	32	302	-	0.12

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars			Hourly ownership cost, dollars		Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer............	524 hp...	24	20.0	6.03	6.00	35.05	5.76	19.40	1,733.76	34,675.20	-	-	-
Do...............	385 hp...	7	20.0	4.39	6.00	28.19	4.78	15.88	414.68	8,293.60	-	-	-
Do...............	440 hp...	6	20.0	5.02	6.00	28.60	4.84	16.10	363.36	7,267.20	-	-	-
Do...............	270 hp...	5	20.0	3.08	6.00	15.80	2.40	7.99	176.35	3,527.00	-	-	-
Scraper..........	24 cu yd.	10	20.0	4.73	6.00	34.08	4.47	12.66	619.40	12,388.00	-	-	-
Do...............	24 cu yd.	10	20.0	5.30	6.00	36.84	4.85	13.75	667.40	13,348.00	-	-	-
Do...............	32 cu yd.	7	20.0	5.70	6.00	39.29	5.14	14.56	494.83	9,896.60	-	-	-
Shovel...........	Large....	4	2.0	42.56	18.00	128.47	112.13	(1)	301.16	2,409.28	-	-	-
Do...............	...do....	1	2.0	67.45	32.00	220.23	166.63	83.31	569.62	1,139.24	-	-	-
Do...............	...do....	1	2.0	168.62	32.00	460.35	378.13	189.06	1,228.16	2,456.32	-	-	-
Do...............	...do....	1	2.0	208.77	32.00	569.96	481.25	240.63	1,532.61	3,065.22	-	-	-
Do...............	Medium...	1	2.0	22.30	18.00	53.53	63.38	(1)	157.21	314.42	-	-	-
Dragline.........	Small....	1	2.0	19.37	12.00	24.59	38.43	19.21	113.60	227.20	-	-	-
									-	99,007.28	9,488	0.18	3.80

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractors, disks, broadcast seeders..........	30	60	42	5	-	39	146	-	0.06
Total reclamation costs..........							9,936	0.18	3.98

---

[1] Completely depreciated.

TABLE B-17. - Estimated reclamation premining planning, backfilling, and revegetation costs for region III, site 5 (1975)

Mining method	Premining planning costs								
	Engineering design		Antipollution measures		Bonds, permits, and fees		Total premining planning costs		
	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Total cost, dollars	Dollars per acre	Dollars per acre	Dollars per cubic yard	Dollars per ton
Area................	11,520	60	38,400	200	4,416	23	283	-	0.06

Equipment	Backfilling equipment--operating and ownership costs												
	Equipment capacity	Quantity	Reclamation, hours per day	Hourly operating cost, dollars				Hourly ownership cost, dollars	Total operating and ownership costs		Total backfilling costs		
				Fuel	Labor	Maintenance	Overhead	Depreciation	Dollars per hour	Dollars per day	Dollars per acre	Dollars per cubic yard	Dollars per ton
Dozer..............	385 hp...	2	20.0	4.39	6.12	28.19	4.78	15.88	118.72	2,374.40	-	-	-
Dragline...........	Medium...	2	4.0	46.69	32.02	30.24	43.65	(1)	152.60	1,220.80	-	-	-
									(2)	(2)	5,354	0.16	1.14

Equipment	Revegetation costs								
	Equipment operating and ownership costs		Soil preparation, dollars per acre			Seeding, dollars per acre	Total revegetation costs		
	Dollars per hour	Dollars per acre	Fertilizer	Lime	Mulch		Dollars per acre	Dollars per cubic yard	Dollars per ton
Farm tractor, disk, seeder............	20	50	30	12	-	27	119	-	0.03
Total reclamation costs..							5,756	0.16	1.23

[1] Completely depreciated.

[2] These columns are not totaled because different pieces of equipment operate a different number of days each year.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1975 O—597—489

3477-199
Lot-S

THE LIBRARY OF CONGRESS

APR 78

BOUND BY HNM

LIBRARY OF CONGRESS
0 002 959 738 8